Original investigation

Development of a Measure of Incremental Behavior Change Toward Smoking Cessation

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Abstract

Introduction: A reliable measure capable of detecting progression towards smoking cessation would be valuable for evaluating and optimizing the effectiveness of low- to moderate-intensity cessation interventions, such as brief advice in the primary care setting. This article presents the development and evaluation of a brief self-report measure of Incremental Behavior Change toward Smoking cessation (IBC-S).

Methods: Sequential samples of 411 and 399 adult smokers completed items representing a spectrum of behavioral and cognitive changes antecedent to smoking cessation. The dimensionality, fit, range of difficulty, and reliability of items were evaluated using factor analysis and Rasch modeling.

Results: The final 15-item IBC-S measure met fit criteria and demonstrated acceptable reliability. Participants with a significant change in IBC-S score were over four times more likely to report cessation at 6-week follow-up (*OR* 4.37, 95% CI 1.83–10.42).

Conclusion: The IBC-S is brief, reliable and associated with self-report of smoking reduction and cessation.

Implications: This article presents the psychometric evaluation of a measure to assess a spectrum of behaviors and cognitions antecedent to smoking cessation. The findings indicate that the items show good measurement properties and good potential as a sensitive measure to evaluate interventions. This measure provides an alternative outcome for interventions that are designed to move individuals towards cessation attempts.

Introduction

Quitting smoking is a process that involves changes in cognitions and behaviors that lead to quit attempts, periods of cessation, and ultimately sustained cessation. Researchers and practitioners have long recognized that the majority of smokers are not ready to quit.^{1–3} Consequently, a realistic objective of offering assistance to unmotivated smokers is to incrementally move those individuals towards

cessation.⁴ The primary approach to evaluate strategies for assisting smokers to quit however, has almost exclusively relied on outcome measures focused on cessation and in particular, achievement of long-term cessation (eg, 6- or 12-month point-prevalence, continuous, or prolonged abstinence).^{5,6} Though these long-term outcome measures have important clinical and public health value, they operationalize smoking cessation as an event rather than a dynamic process as it

has come to be understood.⁵ Further, long-term cessation indicators are temporally distant from the treatment or events that prompted the effort to quit, making evaluation of the effects of assistance and treatment difficult.⁵ The outcome of long-term cessation is particularly misaligned for evaluating cessation interventions with smokers who are largely unmotivated to quit, and for low- to moderate-intensity interventions, such as the provision of brief cessation advice by healthcare providers in the course of routine care. For such interventions, relying on 6- or 12-month abstinence as an outcome may be prone to Type II errors, that is, rejecting interventions that produce relatively few quitters, yet may influence substantial movement towards cessation.⁷ For these contexts in particular, an outcome that measures incremental movement towards cessation would be valuable to evaluate and inform a variety of interventions and approaches.

In 2005, Davis et al. developed a multiple-indicator measure of progress toward smoking cessation. This measure encompassed two dimensions: (1) intention to cut back or quit and (2) behavior change of cutting back or quitting. However, the resulting measure had poor reliability and poor ability to differentiate smokers along the proposed continuum of cessation. The measure included few items applicable to individuals with low levels of motivation to quit.⁷ Nonetheless, these findings represent important conceptual work in developing an outcome measure to assess progress towards smoking cessation.

Our work builds on this concept by expanding it to include a spectrum of behaviors and cognitions antecedent to smoking cessation. The goal of the current study is to develop and evaluate a brief measure of an individual's progress toward smoking cessation. To be useful, the measure must be sensitive to the incremental changes in attitudes and smoking behaviors characteristic of low- to moderate-intensity interventions and applicable for individuals across all levels of motivation to make a quit attempt. This study describes the development, refinement, and psychometric evaluation of the Incremental Behavior Change toward Smoking cessation measure (IBC-S) and, provides evidence for its validity by testing the association with reduction in number of cigarettes smoked and smoking cessation.

Methods

Study Design and Participants

Study data were drawn from three projects with similar sampling and data collection methods. Data were organized and analyzed in two phases; each is briefly described below.

Phase I

Phase I data were drawn from two studies: the Doctor–Patient Communication (DPC1) study and the Prescription for Health study. The DPC1 study was an observational study aimed to identify communication strategies for addressing health behavior change during the doctor–patient encounter.^{8,9} Twenty-eight community-based, primary care physicians from 16 practices in Northeast Ohio were recruited to participate in the study. Data collection included a telephone survey of adult patients scheduled to see an enrolled physician for routine care. Among eligible patients, a total of 1108 patients aged 18–70 participated (47%), of whom 235 self-identified as a current smoker.

The Prescription for Health study was a study designed to evaluate a practice-tailored intervention to improve promotion of healthy behaviors. Study inclusion criteria and data collection methods were similar to the DPC1 study, with the exception of the sampling frame, which was based on the practice as a whole rather than individual physicians. Among eligible patients, a total of 923 patients from

17 primary care practices enrolled in the study during baseline (ie, pre-intervention) data collection (41%); 176 of these patients self-identified as current smokers.

For both the Prescription for Health study and DPC1 study, current smokers (individuals reporting smoking one or more cigarettes per day on average, $n = 411$ total) were asked to respond to 12 items written to measure incremental behavior changes toward smoking cessation. These data, collected between 2005 and 2008, represent our measure development sample.

Phase II

Phase II data were collected between 2010 and 2012 during a second phase of the Doctor–Patient Communication study (DPC2). DPC2 was a group-randomized trial aimed to increase clinician use of the Teachable Moment Communication Process¹⁰ during patient visits to more effectively and efficiently encourage health behavior change. Thirty-one primary care clinicians (family physicians, general internists and nurse practitioners) from 14 community primary care practices were recruited to participate in the study. Patients aged 18–70, presenting for routine care and self-identifying as a cigarette and/or small cigar smoker were invited to participate while waiting to see their provider. Data collection included a pre-visit survey administered in-person at enrollment, and a follow-up survey administered by phone 6 weeks later. Both surveys included assessment of current smoking status/intention to quit and 16 items designed to measure incremental behavior changes toward smoking cessation. Seventy percent of eligible patients agreed to participate. Participants were similar in age, education level, self-reported health status, and reason for visit to those who declined participation, though were more likely to be female and non-white.¹⁰ The 399 patients who self-reported as smokers, and were enrolled during the baseline data collection period of DPC2, represent the measure validation sample in the current analysis. The data collection protocol for each of these studies was reviewed and approved by the Institutional Review Board of University Hospitals of Cleveland.

Measure Development

A pool of incremental behavior change items were written to represent a wide range of behavioral and cognitive changes antecedent to smoking cessation. Item writing was guided by content expert input, from guides about steps to prepare for a quit attempt^{11–13} and a small number of items from the literature that have been used as intermediate outcomes.^{14–16} Items representing cognitions to prepare for a quit attempt were shaped by Cognitive-Behavioral Therapy and focused on thinking about the health consequences of smoking, social consequences of smoking, and thinking about and discussing plans for quitting smoking.^{17,18} Behavioral items focused on doing things to prepare to quit including picking a strategy, picking a date, acquiring resources to help quit (eg, medications, guides) and changing patterns of smoking.^{17,18} Content experts including two representatives from primary care with a focus on addiction and tobacco, two representatives from public health engaged in tobacco cessation work and two ex-smokers provided feedback on individual item wording and collective item content, resulting in modifications to some items. Items then went through multiple iterations of refinement to improve clarity and to achieve an 8th grade or lower reading level. The final version including 12 items was administered to phase I participants.

Based on psychometric evaluation (details described below) of the 12 items used in phase I, some wording was modified, and additional items were written in an effort to fill gaps across the range

of item difficulty. The resulting measure was pilot tested on a convenience sample of adult smokers ($n = 30$) visiting a primary care practice for routine care. This pilot primary care practice was not included in any of the other studies. Item performance was again evaluated, and a cycle of item wording improvements and pilot testing was repeated with a second convenience sample of adult smokers ($n = 30$). A total of 28 items were piloted during these two iterations of testing with the primary goal to determine if gaps across the item difficulty had been filled by the new items. Based on these cycles of refinement, 16 items were selected for further evaluation and were administered during phase II.

Psychometric Evaluation

First, exploratory factor analysis with a principal components solution (SPSS Version 21) was used to evaluate the dimensionality of the item pool. A scree test of a plot of eigen values and factor loadings were used to evaluate dimensionality.¹⁹ Next, a Rasch Rating Scale Model²⁰⁻²² was applied to examine item fit, gapping, range of difficulty, reliability and separation index using WINSTEPS (Version 3.66.0). Item-total correlations were examined as additional evidence for dimensionality. Item total correlations >0.25 were considered sufficient contributors to the latent construct and items meeting this criterion were retained in the scale. Model data fit was evaluated by infit and outfit statistics, with infit and outfit mean square (MNSQ) between 0.5 and 1.5 representing an acceptable range. A MNSQ value <0.5 is a marker of the item being overly predictable and redundant and a MNSQ >1.5 indicates the item is degrading the measurement with more noise than useful information.^{23,24} Evaluation of the items also included examination of the ordering of polytomous response categories.

Two Rasch based reliability statistics were used to evaluate the internal consistency of the measure, person reliability and item-reliability.^{23,25} The person-reliability statistic is comparable to Cronbach's alpha.^{23,25-27} Rasch item-reliability represents the level of confidence that the order of item difficulty would be replicated in another sample of participants. Person-reliability statistics >0.8 and item-reliability statistics >0.9 are considered acceptable.^{23,25} Separation indexes generated from Rasch analyses were also reviewed. A high person-separation index indicates a wide range of ability scores and a high item-separation index indicates that the items cover a useful range of item difficulty. At minimum, separation indexes should be greater than one; values above two are considered good.²³

To further evaluate the items, Wright item-person maps were created to display the location of the respondents and items on a common metric, theta, which follows a distribution like a z score (eg, ranging from -5 to $+5$ with a mean of zero and a SD of 1). Items at the top of the map indicate greater pro-cessation behavior and thus have a higher theta score associated with them. The maps allow for examination of the spread of the items, item redundancy, and gapping in items along the continuum of pro-cessation behavior. Ideally, the item spread should match the spread of the respondents. Item redundancy is present if items fall at the same point on the continuum and point to candidate items to delete if the goal is to reduce the number of items. A theta difference of 0.3 or greater between items on the map indicates a gap. Gaps are positions on the scale with no items to differentiate respondents who might fall at that scale location. A scale with no or few gaps indicates there are sufficient items to differentiate respondents along the continuum of the phenomenon.

Validity Assessment

In order to compute scores representing IBC-S between baseline and the 6-week follow-up survey, the Rasch model solution from baseline was used to anchor the values of the IBC-S items and patient responses at follow-up were then used to generate a score. A positive change score ($T2-T1$) indicates positive change toward cessation from baseline to the 6-week assessment.

Criterion validity was assessed by examining the association of the change score with self-reported reduction in tobacco use and smoking cessation at 6 weeks. IBC-S change scores and 95% confidence intervals (CI) were calculated; the CI was based on the conditional standard error of the respondent's baseline score. IBC-S change scores were considered substantial if they exceeded the upper bound of the CI. Logistic regression was used to evaluate the association of a substantial change score with patient report of smoking cessation at 6 weeks. To control for potential confounding factors, age, gender, race (black, white, Other race), and education level attained were included as covariates in the logistic regression. Among non-quitters, reduction in tobacco use was calculated as the change in number of cigarettes smoked daily between baseline and 6 weeks, with a negative score representing reduction in the number of cigarettes smoked daily. Change in the number of cigarettes is approximately normally distributed; five outliers of more than 20 cigarette increase or decrease were excluded from analyses. Linear regression was used to test the association of IBC-S change scores with change in number of cigarettes smoked, controlling for potential confounding factors, age, gender, race, and education level attained. Associations were evaluated as significant at $p < .05$.

Results

Study Participants

Phase I and phase II patient characteristics are displayed in Table 1. In both samples, patients reported smoking an average of about 12 cigarettes per day. Patients reported a high level of importance of quitting and less confidence in quitting. About one-third of patients indicated that they intend to quit in the next month; about one-fifth expressed no intention to quit in the next year (Table 1). Among the phase II participants, 94% completed the 6-week survey. There were no significant differences between completers and non-completers in age, gender, race, level of education attained, or level of intention to quit smoking assessed at baseline.

Phase I Measure Properties

Exploratory factor analysis of the initial pool of 12 items administered in phase I identified one underlying factor; thus the assumption of unidimensionality for Rasch analysis was met. Table 2 shows the full item stem, response categories and the frequency of response. Next, Table 3 shows the Rasch model statistics including item difficulties, infit and outfit estimates, item-total correlation, item and person separation index, and item and person reliability. Findings for the analysis of phase I data are on the left side of the table. Items are ordered by item theta score expressed in logits from the item representing the lowest pro-cessation behavior to the item representing the highest pro-cessation behavior. Eleven of the 12 items had infit and outfit MNSQ values within the acceptable range (0.5 to 1.5) and all item-total correlations were >0.25 , indicating that each item was generally consistent in measuring the same underlying construct. Other evaluation criteria were in the acceptable range. The spread

Table 1. Patient Demographic, Health, and Smoking Characteristics

	Phase I (<i>n</i> = 411)	Phase II (<i>n</i> = 399)
Patient characteristics	mean ± <i>SD</i>	mean ± <i>SD</i>
Age	48.4 ± 11.4	44.5 ± 13.0
Race	<i>n</i> (%)	<i>n</i> (%)
White	158 (39)	239 (61)
Black/ African American	233 (57)	133 (34)
Other	16 (4)	18 (5)
Hispanic	10 (2)	30 (8)
Male	99 (24)	158 (40)
Education		
Less than high school graduate	72 (18)	70 (18)
High school graduate or GED	152 (37)	139 (35)
Some college	128 (31)	135 (34)
College degree	59 (14)	54 (14)
Chronic conditions		
None	142 (35)	184 (47)
One	140 (34)	114 (29)
Two or more	125 (31)	95 (24)
Self-reported health status		
Excellent	15 (4)	22 (6)
Very good	80 (20)	66 (17)
Good	156 (38)	134 (34)
Fair	122 (30)	119 (30)
Poor	38 (9)	57 (14)
Smoking characteristics	mean ± <i>SD</i>	mean ± <i>SD</i>
Average cigarettes smoked per day ^a	11.7 ± 10.0	12.0 ± 9.0
Importance to quit smoking, from 1 to 10	8.8 ± 2.2	7.8 ± 2.6
Confidence can quit smoking, from 1 to 10	6.5 ± 2.8	6.3 ± 2.9
Intention to quit smoking	<i>n</i> (%)	<i>n</i> (%)
In the next month	132 (34)	102 (27)
In the next 6 months	149 (38)	100 (27)
In 6 months to 1 year	50 (13)	89 (24)
Not in the next year	60 (15)	84 (22)

^aFor phase II, cigarettes smoked per day represents daily consumption of cigarettes and small cigars combined, with one small cigar considered equivalent to three cigarettes.

of the items and gaps in items is best presented in the Wright item-person map (Figure 1) with phase I data presented on the left. For phase I, the mean of the distribution of items and respondents along the continuum of change towards cessation were well matched. However, large gaps between items along the continuum were evident. Specifically, items were lacking at both the low and high ends of the spectrum. Also, some items were redundant (ie, items 6 and 8). Further, some items had mis-ordered response categories and these items were dropped from further consideration. Based on these findings, several items were reworded and new items were written. The revised measure was pilot tested and then used in the phase II data collection.

Phase II Measure Properties

Factor analysis of the 16 items identified a single underlying dimension. The 16-item Rasch model identified one item with a very low item-total correlation (0.17) and this was excluded from further consideration. Table 2 shows the Rasch model item and fit statistics from the resulting final 15-item IBC-S measure. All infit and

outfit MNSQ values were within the acceptable range of 0.5 to 1.5. Compared to the phase II measure, this 15-item IBC-S measure had a higher item separation index (9.98 vs. 7.35) and better coverage at the extremes of the scale. Two newly added items, item 13: “I have a prescription from my doctor to help me quit smoking” and item 5: “I have thought about strategies to quit smoking,” represent the highest and lowest items along the continuum, respectively. The person reliability is 0.71, considered acceptable, and the item reliability is 0.99, which is excellent.

As shown on the right side of Figure 1, compared to the 12-item measure, the 15-item measure has greater spread, with item difficulty scores ranging from −2.16 to 1.54. While this spread of items is improved, the mean score of the final items was somewhat higher than the mean person ability (0 vs. −0.84). This suggests that the 15-item IBC-S is fairly well-matched to the sample, but this pool of respondents is somewhat less likely to endorse items higher on the pro-cessation continuum than expected with this model. The newly written items appear to have filled gaps, but three modest-sized gaps remain.

Measure Validity

Next, using the 15 items, baseline and the 6-week follow-up scores were computed. Independent of age, gender, race, and education level, participants whose IBC-S score changed substantially from baseline to follow-up were over four times more likely to report cessation than were those whose change scores were not substantial (OR 4.37, 95% CI 1.83–10.42). Among those individuals who reported continued smoking at the 6-week follow-up, a positive change in IBC-S score showed a modest association with a decrease in daily cigarette consumption $B = -0.82$ (SE 0.32, $t = -2.73$, $p = .007$), independent of age, gender, race and education level.

Discussion

The slowing rate of decline in smoking prevalence in the United States in recent years, despite the existence of numerous evidence-based tobacco cessation interventions, suggests a need for research initiatives focused on optimizing currently recommended tobacco treatment strategies. To this end, measures capable of detecting the small behavior changes antecedent to smoking cessation that may arise from low- to moderate-intensity interventions could be valuable. Further, as much of the existing smoking intervention literature has been carried out with smokers who are motivated to quit, a measure that is applicable to individuals across all levels of readiness to quit is needed.⁵

The brief IBC-S measure assessed in this study addresses both of these methodological concerns and provides a valid and sensitive tool for the assessment of tobacco cessation in clinical settings. The IBC-S builds on the existing smoking cessation related measures that assess intention to change⁷ and the psychological processes of change.^{14,15} Accordingly, the IBC-S was specifically designed to represent a spectrum of incremental steps from cognitions to actions antecedent to cessation. The current psychometric evaluation supports its ability to reliably detect the dynamic attitudes and behaviors indicative of individual progression toward cessation among a diverse sample of smokers. Further, the observed association of the IBC-S with self-report of smoking reduction and cessation provides initial evidence for validity of the measure.

The strengths of this study include large sample sizes for both the instrument development and validation phase drawn from

Table 2. Item Stems, Response Categories, and Frequency of Response^a

Item #	Item stem	Response options	Response frequency sample 1 (N = 411)	Response frequency sample 2 (N = 399)
1.	I've talked with someone about how they quit smoking in the past year.	No Yes		133 (33.5) 264 (66.5)
2.	I have picked a quit date.	No Yes	266 (76.9) ^b 80 (23.1)	332 (83.6) 65 (16.4)
3.	I worry about how smoking is affecting my health.	Never Rarely Sometimes Often Always	31 (7.6) 24 (5.9) 56 (13.7) 150 (36.7) 148 (36.2)	19 (4.8) 23 (5.8) 125 (31.6) 117 (29.5) 112 (28.3)
4.	As a way of cutting back, I smoke less than a full cigarette or small cigar.	No Yes		156 (39.4) 240 (60.6)
5.	I have thought about strategies to quit smoking.	No Yes	158 (38.4) 253 (61.6)	100 (25.3) 296 (74.7)
6.	I have picked a strategy for quitting that might work for me.	No Yes	116 (46.0) ^b 136 (54.0)	254 (64.3) 141 (35.7)
7.	I currently have nicotine replacement products (eg, gum, patch).	No Yes		340 (85.4) 58 (14.6)
8.	I feel uncomfortable when I think about my smoking.	Never Rarely Sometimes Often Always	100 (24.4) 69 (16.8) 67 (16.3) 106 (25.9) 68 (16.6)	86 (22.0) 56 (14.3) 138 (35.3) 61 (15.6) 50 (12.8)
9.	In the past month, I have sought help to quit smoking (eg, from a healthcare provider, friend, or family member).	No Yes	301 (73.4) 109 (26.6)	327 (82.0) 72 (18.0)
10.	In the past month, I have gotten rid of things that I use while smoking (eg, lighter, ash tray, cigarette case).	No Yes		344 (87.3) 50 (12.7)
11.	I worry about what other people think of my smoking.	Never Rarely Sometimes Often Always		122 (31.0) 55 (14.0) 129 (32.7) 52 (13.2) 36 (9.1)
12.	I stopped buying cigarettes and/or small cigars.	No Yes		345 (86.7) 53 (13.3)
13.	I have a prescription from my doctor to help me quit smoking.	No Yes		349 (87.9) 48 (12.1)
14.	I think I have done everything I can to set myself up for success to quit smoking.	No Yes	228 (67.1) ^b 112 (32.9)	316 (80.00) 79 (20.00)
15.	I have told my friends or family about my plans to quit smoking.	No Yes	128 (36.9) ^b 219 (63.1)	198 (49.9) 199 (50.1)
Items dropped from further consideration				
A.	When you are tempted to smoke, how often do you think about or do something else? ^c	Never Rarely Sometimes Often Always	60 (14.7) 92 (22.6) 131 (32.2) 90 (22.1) 34 (8.4)	
B.	How often do you think about what it would be like as a non-smoker? ^c	Never Rarely Sometimes Often Always	45 (11.0) 56 (13.7) 66 (16.1) 146 (35.6) 97 (23.7)	
C.	How often does it bother you that your smoking may affect people you care about?	Never Rarely Sometimes Often Always	36 (8.8) 25 (6.1) 61 (14.9) 139 (34.0) 148 (36.2)	
D.	Have you looked into medications that can help you quit smoking (eg, gum, the patch or Zyban)?	No Yes	243 (59.3) 167 (40.7)	
E.	I personally know someone who has quit in the past year.	No Yes		165 (41.6) 232 (58.4)

^aBlank cells indicate that item was not administered to sample.^bMissing or Not Applicable exceeds 10%.^cItem idea source.¹²

Table 3. Item Statistics for the Phase I 12-Item and Phase II Final 15-Item IBC-S Measure, Ordered by Difficulty of the Final Measure

Phase I 12-item measure, <i>n</i> = 411					Phase II final 15-item measure, <i>n</i> = 399				
Score (SE)	Infit MNSQ (ZSTD)	Outfit MNSQ (ZSTD)	Item-Totals Correlation	Item ^a	Item	Score (SE)	Infit MNSQ (ZSTD)	Outfit MNSQ (ZSTD)	Item-total correlation
1.41 (0.14)	0.99 (-0.1)	1.00 (0.1)	0.37	13.	Have a prescription	1.54 (0.16)	1.05 (0.5)	1.04 (0.3)	0.26
1.06 (0.12)	0.91 (-1.5)	0.81 (-2.2)	0.46	10.	Gotten rid of things	1.48 (0.16)	0.98 (-0.2)	0.90 (-0.4)	0.32
0.84 (0.12)	1.10 (1.8)	1.18 (2.4)	0.26	12.	Stopped buying cigs	1.42 (0.16)	1.04 (0.4)	1.13 (0.7)	0.26
0.30 (0.11)	1.01 (0.3)	1.02 (0.4)	0.38	7.	Nicotine replacement products	1.30 (0.15)	1.01 (0.1)	1.07 (0.5)	0.29
0.09 (0.06)	1.57 (7.5)	1.62 (7.9)	0.42	2.	Picked a quit date	1.13 (0.15)	0.92 (-0.9)	0.72 (-1.8)	0.41
0.06 (0.13)	1.07 (1.7)	1.09 (1.3)	0.26	9.	Sought help to quit	1.00 (0.14)	1.00 (0.0)	1.22 (1.4)	0.33
-0.57 (0.05)	0.87 (-2.0)	0.85 (-2.1)	0.68	14.	Set self up for success	0.85 (0.14)	1.01 (0.2)	1.03 (0.3)	0.33
-0.02 (0.05)	0.83 (-2.8)	0.82 (-2.5)	0.70	D.	Looked into medications				
-0.61 (0.12)	0.92 (-1.8)	0.87 (-1.8)	0.42	A.	Think or do something else				
-0.90 (0.05)	1.03 (0.4)	1.13 (1.4)	0.62	6.	Picked a quit strategy	-0.10 (0.12)	1.05 (1.1)	1.05 (0.7)	0.36
				11.	Worry what others think	-0.26 (0.05)	1.10 (1.4)	1.07 (0.9)	0.64
				B.	Think about being nonsmoker				
				8.	Feel uncomfortable about	-0.58 (0.06)	0.92 (-1.2)	0.90 (-1.4)	0.71
				15.	Told friends or family plans	-0.82 (0.11)	0.86 (-3.5)	0.82 (-2.9)	0.54
				C.	Bothered affects people				
				4.	Smoke less than full cig	-1.35 (0.11)	1.19 (3.9)	1.26 (3.3)	0.27
				1.	Talked with someone	-1.66 (0.12)	1.02 (0.5)	1.06 (0.7)	0.40
-0.97 (0.06)	0.91 (-1.1)	0.89 (-1.3)	0.65	3.	Worry smoking affects health	-1.77 (0.06)	0.98 (-0.2)	1.00 (0.0)	0.67
-0.71 (0.11)	0.86 (-3.6)	0.84 (-2.5)	0.50	5.	Thought about quit strategies	-2.16 (0.13)	0.85 (-2.4)	0.80 (-1.8)	0.53
Fit statistics: Item separation 7.35 and reliability 0.98; Person separation 1.55 and reliability 0.71					Fit statistics: Item separation 9.98 and reliability 0.99; Person separation 1.56 and reliability 0.71				

IBC-S = Incremental Behavior Change toward Smoking cessation; MNSQ = mean square; ZSTD = z standardized; SE = standard error. One additional item (E, "know someone who quit") was administered in phase II but was dropped from the final measure due to low item-total correlation. Its fit statistics in the preliminary 16-item model were: Score = -1.14 (0.11); Infit MNSQ = 1.26 (5.7); Outfit MNSQ = 1.38 (5.2); Item-total correlation = 0.17.

^aItem numbers refer to item order on the phase II survey (less item E); lettered items (A–D) represent dropped phase I measure items.

Figure 1. Wright item-person maps for the phase I 12-item and phase II final 15-item Incremental Behavior Change toward Smoking cessation (IBC-S) measure. *Note:* Mean person scores (indicated by M on the person axes) were -0.15 for the measure development (phase I) sample and -0.84 for the measure validation (phase II) sample. ^aItem numbers refer to item order based on the phase II survey; lettered items (A–D) represent dropped phase I measure items.

community-based practices serving patients with a wide range of demographic and health characteristics. Additionally, because our patient samples were not recruited from high-intensity smoking cessation programs, various levels of readiness to make a quit attempt at baseline were represented in the evaluation of the items. Finally, the use of Rasch modeling to rigorously examine the psychometric properties of the measure is another notable strength.

Several limitations of this work should also be noted. Our assessment of the validity of the 15-item IBC-S measure is limited to self-report at 6 weeks. Additional validity testing including using a known groups approach (eg, exposure to a known successful cessation intervention) to assess the responsiveness of the measure and testing the predictive validity with longer follow-up and biomarker confirmation of cessation is warranted. The concurrent timing of the assessment of cessation and the IBC-S items at follow-up in phase II is another study limitation. IBC-S items represent behavioral and cognitive changes antecedent to smoking cessation, thus several items may not be applicable after quitting (eg, picking a quit date or smoking less than a full cigarette prior to quitting). Therefore,

additional study with assessment at multiple time points prior to cessation would be helpful to more accurately assess the association of change in the IBC-S score and smoking cessation.

The participants in this study were drawn from those seeking routine primary care. Overall participants were similar to those in other practice-based research network studies conducted in similar samples of practices.²⁸ We did not assess for use of electronic nicotine devices and are unable to comment on how this measure would perform with electronic nicotine device users or dual tobacco users. However, further testing of the performance of the measure with a wide range of smokers (ie, non-daily, daily, heavy), from a variety of settings is warranted and may confirm the need to write additional items to fill gaps. Finally, it is particularly important to assess the association of the IBC-S with additional outcomes which will contribute to understanding the usefulness, reliability and validity of the measure.

Although this article mainly presents the development and psychometric properties of the IBC-S, it also demonstrates some promising preliminary findings of the utility of the measure. The instrument is brief, easy to administer in the clinical setting and can provide

information useful to clinicians regarding where an individual is along a cessation continuum. Further, because items fall along a continuum of behaviors, clinicians may find it useful to recommend the next behaviors on the continuum as a small step for individual change. As a sensitive measure of change applicable to smokers exhibiting a wide range of readiness to quit, the IBC-S is ideally suited to evaluate low- to moderate-intensity cessation interventions, or potentially to assess intermediate effects during high-intensity programs, including those in studies designed to prompt initiation of treatment or quit attempts.

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Declaration of Interests

None declared.

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References

1. Velicer WF, Fava JL, Prochaska JO, Abrams DB, Emmons KM, Pierce JP. Distribution of smokers by stage in three representative samples. *Prev Med (Baltim)*. 1995;24(4):401–411. doi:10.1006/pmed.1995.1065.
2. Centers for Disease Control and Prevention (US); National Center for Chronic Disease Prevention and Health Promotion (US); Office on Smoking and Health (US). *How Tobacco Smoke Causes Disease: The Biology and Behavioral Basis for Smoking-Attributable Disease: A Report of the Surgeon General. Chapter 4. Nicotine Addiction: Past and Present*. Atlanta, GA: Centers for Disease Control and Prevention (US); 2010. www.ncbi.nlm.nih.gov/books/NBK53017/. Accessed July 23, 2016.
3. Abrams D, Niaura R, Brown RA, Emmons KM, Goldstein MG, Monti PM. *The Tobacco Dependence Treatment Handbook: A Guide to Best Practices*. New York, NY: Guilford Press; 2003.
4. Fiore M, Jaén C, Baker T, Bailey W, Bennet G, Benowitz N. A clinical practice guideline for treating tobacco use and dependence: 2008 update. *Am J Prev Med*. 2008;35(2):158–176. doi:10.1016/j.amepre.2008.04.009.
5. Baker TB, Mermelstein R, Collins LM, et al. New methods for tobacco dependence treatment research. *Ann Behav Med*. 2011;41(2):192–207. doi:10.1007/s12160-010-9252-y.
6. Velicer WF, Prochaska JO, Rossi JS, Snow MG. Assessing outcome in smoking cessation studies. *Psychol Bull*. 1992;111(1):23–41. www.ncbi.nlm.nih.gov/pubmed/1539088. Accessed November 14, 2015.
7. Davis MF, Sechrest LB, Shapiro D. Measuring progress toward smoking cessation. *J Appl Meas*. 2005;6(2):164–172.
8. Flocke SA, Clark E, Antognoli E, et al. Teachable moments for health behavior change and intermediate patient outcomes. *Patient Educ Couns*. 2014;96(1):43–49. doi:10.1016/j.pec.2014.03.014.
9. Cohen DJ, Clark EC, Lawson PJ, Casucci BA, Flocke SA. Identifying teachable moments for health behavior counseling in primary care. *Patient Educ Couns*. 2011;85(2):e8–e15. doi:10.1016/j.pec.2010.11.009.
10. Flocke SA, Antognoli E, Step MM, Marsh S, Parran T, Mason MJ. A teachable moment communication process for smoking cessation talk: description of a group randomized clinician-focused intervention. *BMC Health Serv Res*. 2012;12(1):109. www.ncbi.nlm.nih.gov/pubmed/22554310. Accessed December 8, 2012.
11. American Cancer Society. American Cancer Society Guide to Quitting Smoking. www.cancer.org/healthy/stayawayfromtobacco/guidetoquittingsmoking/index. Accessed July 15, 2016.
12. Smokefree.gov. <https://smokefree.gov/build-your-quit-plan>. Accessed July 15, 2016.
13. Agency for Healthcare Research and Quality. Help for Smokers and Other Tobacco Users. 2008. www.ahrq.gov/professionals/clinicians-providers/guidelines-recommendations/tobacco/clinicians/tearsheets/helpsmokers.html. Accessed July 15, 2016.
14. Hoepfner BB, Velicer WF, Redding CA, et al. Psychometric evaluation of the smoking cessation Processes of Change scale in an adolescent sample. *Addict Behav*. 2006;31(8):1363–1372. doi:10.1016/j.addbeh.2005.11.002.
15. Prochaska JO, Velicer WF, DiClemente CC, Fava J. Measuring processes of change: applications to the cessation of smoking. *J Consult Clin Psychol*. 1988;56(4):520–528.
16. Engels RC, Knibbe RA, de Vries H, Drop MJ. Antecedents of smoking cessation among adolescents: who is motivated to change? *Prev Med (Baltim)*. 1998;27(3):348–357. <http://dx.doi.org/10.1006/pmed.1998.0304>. Accessed March 10, 2013.
17. Perkins KA, Conklin CA, Levine MD. Preparing smokers to quit. In: *Cognitive-Behavioral Therapy for Smoking Cessation*. New York, NY: Routledge; 2008:31–67.
18. Perkins KA, Conklin CA, Levine MD. Time to quit. In: *Cognitive-Behavioral Therapy for Smoking Cessation*. New York, NY: Routledge; 2008:69–93.
19. Costello AB, Osborne JW. Best practices in exploratory factor analysis: four recommendations for getting the most from your analysis. *Pract Assess Res Eval*. 2005;10(7):1–9. doi:10.1111/j.1442-9993.2009.02074.x.
20. Andrich D. A rating formulation for ordered response categories. *Psychometrika*. 1978;43(4):561–573. doi:10.1007/BF02293814.
21. Wright B, Masters G. *Rating Scale Analysis*. Chicago, IL: MESA Press; 1982.
22. Rasch G. *Probabilistic Models for Some Intelligence and Attainment Tests*. Chicago, IL: University of Chicago Press; 1980.
23. Linacre JM. Winsteps® Rasch measurement computer program User's Guide. Beaverton, OR: 2016. www.winsteps.com/manuals.htm. Accessed July 23, 2016.
24. Bond TG, Fox CM, eds. *Applying the Rasch Model: Fundamental Measurement in the Human Sciences*. 1st ed. Mahwah, NJ: Lawrence Erlbaum Associates Inc; 2001.
25. Wright BD, Stone MH. *Measurement Essentials*. 2nd ed. Wilmington, DE: Wide Range, Inc; 1988.
26. Clauser B, Linacre JM. Relating Cronbach and Rasch reliabilities. *Rasch Meas Trans*. 1999;13(2):696. www.rasch.org/rmt/rmt132i.htm. Accessed July 23, 2016.
27. Linacre JM. KR-20 / Cronbach alpha or Rasch person reliability: which tells the truth. *Rasch Meas Trans*. 1997;11(3):580–581. www.rasch.org/rmt/rmt113l.htm. Accessed July 23, 2016.
28. Stange KC, Zyzanski SJ, Jaén CR, et al. Illuminating the 'black box'. A description of 4454 patient visits to 138 family physicians. *J Fam Pract*. 1998;46(5):377–389.