Research Article

Development of a Comprehensive Heart Disease Knowledge Questionnaire

Hannah E. Bergman, Bryce B. Reeve, Richard P. Moser, Sarah Scholl, and William M. P. Klein

ABSTRACT

Background: *Heart disease is the number one killer of both men and women in the United States, yet a comprehensive and evidence-based heart disease knowledge assessment is currently not available.* ***Purpose:*** *This paper describes the two-phase development of a novel heart disease knowledge questionnaire.* ***Methods:*** *After review and critique of the existing literature, a questionnaire addressing five central domains of heart disease knowledge was constructed. In Phase I, 606 undergraduates completed an 82-item questionnaire. In Phase II, 248 undergraduates completed a revised 74-item questionnaire. In both phases, item clarity and difficulty were evaluated, along with the overall factor structure of the scale.* ***Results:*** *Exploratory and confirmatory factor analyses were used to reduce the scale to 30 items with fit statistics, CFI = .82, TLI = .88, and RMSEA = .03. Scores were correlated moderately positively with an existing scale and weakly positively with a measure of health literacy, thereby establishing both convergent and divergent validity.* ***Discussion:*** *The finalized 30-item questionnaire is a concise, yet discriminating instrument that reliably measures participants' heart disease knowledge levels.* ***Translation to Health Education Practice:*** *Health professionals can use this scale to assess their patients' heart disease knowledge so that they can create a tailored program to help their patients reduce their heart disease risk.*

Bergman HE, Reeve BB, Moser RP, Scholl S, Klein WMP. Development of a comprehensive heart disease knowledge questionnaire. Am J Health Educ. *2011;42(2):74-87. This paper was submitted to the* Journal *on August 5, 2010, revised and accepted for publication on November 19, 2010.*

BACKGROUND

For over 80 years, heart disease has been the leading cause of mortality for both men and women in the United States.[1,2] In 2005, heart disease claimed the lives of more than 860 000 Americans.[3] Coronary heart disease (CHD), the most common type of heart disease in the U.S.,[4] is responsible for about 500 000 deaths per year.[3] Results from the National Heart, Lung, and Blood Institute's Framingham Heart Study found that the lifetime risk for developing CHD at age 40 is a 1-in-2 chance (48.6%) for men and 1-in-3 chance (31.7%) for women.[4] Moreover, it is estimated that every 30 seconds an American will suffer from a coronary event and every 60 seconds the event is fatal.[3]

Not only is heart disease the number one killer of Americans, but some of the disease's modifiable risk factors comprise the leading three direct contributors to death in the U.S.: tobacco use, poor diet and physical inactivity, and alcohol consumption.[5] Other modifiable risk factors for developing heart disease include obesity, high blood pressure, high blood cholesterol, and stress.[6] Thus, much of an individual's risk of heart disease—and likewise, of death—can be

Hannah E. Bergman is a cancer research training award fellow at the National Cancer Institute, Rockville, Maryland 20852; E-mail: bergmanhe@mail.nih.gov. Bryce B. Reeve is an associate professor at The University of North Carolina at Chapel Hill, CB 741, Chapel Hill, NC 27599-7411. Richard P. Moser is a research psychologist, National Cancer Institute, Room 4052, Rockville, MD 20852. Sarah Scholl is a project manager, University of Pittsburgh, Pittsburgh, PA 15213. William M. P. Klein is an associate director, National Cancer Institute, Room 4060, Rockville, MD 20852.

mitigated by addressing one or more of these modifiable factors through individual means such as by quitting smoking, exercising, improving diet, or obtaining medical treatment for conditions such as diabetes, high blood pressure, or unhealthy blood cholesterol.

Heart disease will continue to be a modern-day health threat unless the American public has a clear and comprehensive understanding of what, and how, risk factors contribute to the development of the disease. Further, individuals need not only be able to identify their risk factors, but also to understand them in the context of overall heart health knowledge. Ensuring that individuals possess a basic understanding of the disease itself—including its symptomatology, as well as related medical and dietary knowledge—will enable them to identify specific actions they can take to reduce their risks and to build a foundation upon which they can effectively take control of their health. Hence, having the ability to assess peoples' level of knowledge about heart disease through a standardized tool would be valuable in aiding the design of effective health interventions, as well as in measuring the efficacy of such interventions. In addition, such a tool could effectively serve as a means by which to tailor educational materials to individuals directly, to address their specific gaps in knowledge.

PURPOSE

The goal of the current study was to develop an easily-administered and psychometrically sound heart disease knowledge questionnaire that could be used in a variety of adult populations. To achieve our purpose, we identified and extracted selected items from existing scales, merging them with newly developed items based on current cardiovascular research. The current scale encompasses five relevant knowledge domains: dietary knowledge, epidemiology, medical information, risk factors, and heart attack symptoms. Sources for the existing and new items are reported in the Methods section.

The questionnaire was developed in two phases. The first phase (Phase I) was exploratory; we developed and tested a paper and pencil 84-item questionnaire with a university student sample. The primary goals were to validate the questionnaire's five-domain structure and to reduce the number of items. We also included additional items that evaluated participants' perceptions of their heart disease knowledge. In Phase II, we validated a refined version of the scale with a second university student sample.

We identified existing measures of heart disease knowledge through a search of literature published as of February 2010 using PubMed and PsycINFO databases and Google Scholar. Articles reviewed were restricted to those written in English, with no limits on year of publication. We used keyword search combinations such as: "heart health" and/or "heart disease" with "knowledge," "development of," "test," "scale," "questionnaire," and "assessment" to find related articles. We did not review scales that included a majority of open-ended or Likert-scale type questions where there was not an obvious correct answer[7-11] or scales that focused specifically on detection, as opposed to more general knowledge of heart disease.[12] We also excluded from the review any studies that included participants aged 18 and younger,[10,13,14] since the current study's samples comprised of participants 18 and older. Sixteen scales ultimately met our criteria for review.

Each of the 16 scales was examined using a set of criteria developed by the authors that were based on scale construction, administration and scoring. Within scale construction, degree of comprehensiveness (evaluation of how many knowledge domains were addressed), degree of generalizability, understandability and suitability of wording, degree of difficulty of the questions, and total number of items were evaluated. Scale administration review involved assessing mode of administration, as well as sample group and sample size (i.e., whether the scale could be used on multiple population samples and was tested on a large enough sample size). Finally, our assessment of scale scoring took into account incorporation of open-ended items and use of continuous response scales (e.g., Likert-type scales). Our review process revealed many issues (addressed in the critique below) with the existing scales and led us to believe that our current scale would not only address these issues, but add to the field of cardiovascular disease patient education by providing a more comprehensive and updated scale. See Table 1 for summary of findings.

Many scales only addressed a subset of the five domains.[15-19] Others were tailored specifically either to participants in an intervention program or to patient subpopulations.[16,17,20-23] In other cases, item wording was outdated or the use of terminology was too technical. For example, scales that contain terms such as "angina pectoris," "atherosclerosis"[24,25] and "myocardial infarction"[18,23] may not be practical for those with low levels of education.

Some scales may also lead to ceiling effects in performance. For example, among the 25 items used in the Heart Disease Fact Questionnaire,[22] 18 items were found to have a mean difficulty score of .80 or above, meaning that the majority of the items were answered correctly 80% of the time by participants. Without inclusion of items having a broader range of difficulty, such scales do not allow for the detection of meaningful differences in knowledge. Further, many scales contain too few or too many items. A scale with too few items may not adequately measure individuals' knowledge levels with sufficient sensitivity, and may also raise content validity concerns.[24,26,27] Conversely, a scale with too many items increases respondent burden and may render it impractical for use in settings in which time may be limited, such as during visits with health practitioners.[25,28,29]

The modes by which some scales were administered may have generated invalid results, such as those conducted via telephone[27,29] or otherwise in the form of an oral interview.[18,27] Administering a scale verbally introduces the possibility of interviewer bias or inconsistency. Further, respondents are also more likely to answer in socially desirable ways when surveyed orally.[31] Another problem is utilization of a small sample.[29]

Table 1. Criteria Met by the Previous Scales

Authors	Year	Scale Construction			
		Comprehensive	Generalizability	Wording	Item Difficulty
Collins et al.	2004		x[a]	x	NR[b]
DeForge et al.	1998			x	NR
Farquhar et al.	1990	x	x		NR
Folsom et al.	1988	x	x	x	x
John et al.	2009			x	
Momtahan et al.	2004		x		x
Mosca et al.	2000	x	x	x	NR
Mosca et al.	2004	x	x	x	NR
Oliver-McNeil & Artinian	2002	x	x	x	NR
Smith et al.	1991	x			NR
Suminski et al.	1999	x	x	x	
Tate & Cade	1990		x	x	
Thanavaro et al.	2006	x	x		NR
Thanavaro et al.	2010	x		x	x
Wagner et al.	2005a	x		x	NR
Wagner et al.	2005b	x		x	

Notes:
[a]An "x" indicates criterion met by a particular scale.
[b]Not reported "NR" indicates that item difficulty criterion was not reported or that it was not reported for all items.
[c]An "x" indicates articles that *did not* include open-ended or continuous response items.
[d]An "x" indicates articles that *did* include the answer option "I don't know."

Scales which utilize open-ended or continuous response items are challenging for the administrator to score.[18,27-30] Open-ended questions elicit a wide range of responses and as such, are difficult to score objectively.[32] The use of items with continuous response scales renders determining "correct" answers problematic, because no clear correct response exists. Further, several scales were also found to contain true/false items, but did not include the "I don't know" option as a choice.[16,17,19,20,23,24,26,27,30] Including this option helps to reduce guessing.[32]

Our aim was to address these issues via construction of a novel scale—one based upon the most current medical knowledge about heart disease and its risk factors, epidemiology, and symptoms that would add to the field of cardiovascular disease patient education. We did so using two samples and cross-validated the resulting scale by correlating it with a previously used scale,[26] as well as a common measure of health literacy,[33] to establish both convergent and divergent validity.

METHODS

Instrument Development

The current scale encompasses five relevant knowledge domains: dietary knowledge, epidemiology, medical information, risk factors, and heart attack symptoms. These current domains were derived from our literature review of previous scales, the self-regulatory model of illness behavior literature,[34,35] and the findings from an ad hoc expert panel consisting of a board certified internist, a health psychologist, and psychometrician. Based on our findings, these five domains are of equal importance in the realm of heart disease knowledge.

The self-regulatory model of illness behavior stipulates that individuals make health decisions over three stages: cognitive representations stage, action plan stage, and appraisal stage.[36] The cognitive representation stage is defined by five dimensions of the health risk: identity/characteristic symptoms, cause, consequences, duration, and control.[36-39] We believe that our domains, and their associated items, conform

Table 1. Criteria Met by the Previous Scales

	Administration		Scoring	
# of Items	Mode	Sample	Open-ended/ Continuous Response[c]	"I don't know"[d]
X	X	X	X	X
X	X	X	X	
	X	X	X	
		X		
X	X	X	X	
X		X		X
		X		X
X		X		
	X			X
	X	X	X	
	X	X	X	
X	X	X	X	
X	X	X	X	X
X	X	X	X	
X	X	X	X	X
X	X	X	X	X

to this stage of the self-regulation model of illness.

The selection of existing items and development of new ones were based on how the items fell within the five pre-established knowledge domains. The process was undertaken by the authors, including a health psychologist, a research psychologist and a psychometrician. Some items were extracted from existing, yet dated scales, such as the Cardiovascular Disease (CVD) Knowledge Test,[26] while others were developed using findings and information gleaned from the Pittsburgh Healthy Heart Study, American Heart Association, Harvard Center for Cancer Prevention, Women's Heart Foundation, Heart Healthy Women, National Heart, Lung and Blood Institute, National Center for Health Statistics, Department of Health and Human Services, United States Department of Agriculture, Centers for Disease Control and Prevention, Mayo Clinic, University of Maryland Medical Center, Harvard Medical School, and Coalition of Labor Union Women.

The true-false format was chosen over the multiple-choice item format for the current scale because we wanted to reduce participant burden, given that there were over 80 items in the original questionnaire (see Phase I instrument description). The "I don't know" option was included to help improve the scale's reliability to reduce guessing that is often associated with the true-false format.[32]

An ad hoc panel was created to address and review the content validity and face validity of the domains and items selected for the finalized questionnaire (as seen in Phase II methods and results). The group was composed of three experts in cardiovascular disease, health psychology and psychometrics. The three experts were asked to independently check to see if the items had the correct response, fit under the pre-established domain, and were up-to-date.

Phase I Questionnaire

Instrument description. The initial questionnaire consisted of 82 items that measured dietary knowledge ($N = 20$), epidemiology knowledge ($N = 8$), medical knowledge ($N = 24$), risk factors knowledge ($N = 20$), and

heart attack symptoms knowledge ($N = 10$). Additionally, participants completed three items that measured their self-perceived degree of knowledge about heart disease: "I know more than the average person about heart disease," "I believe that I answered 75% or more of the above questions correctly," and "I believe that I answered more of the above questions correctly than the average person will." Participants also reported age and gender.

Participants. Participants were 606 University of Pittsburgh undergraduates enrolled in an introductory psychology course. Participants were 56.6% female with a mean age of 18.67 (SD = 1.66, range = 17 to 44). Three participants did not provide demographic information. Participation fulfilled a course requirement.

Procedure. Participants completed the scale as part of a mass testing session. The instructions for the heart disease questionnaire asked the participants to answer "true," "false," or "I don't know" to a number of questions addressing their beliefs and knowledge about various aspects of heart disease.

Data preparation. From the original 82 items, we excluded 9 items—8 of which were no longer accurate based on new findings in the medical literature at the time of analysis (for example, "*Lack of physical activity is the principal cause of obesity*," is incorrect since it is now understood that no 1 principle cause of obesity exists)[40] and 1 item due to ambiguity ("*Men and women experience the same symptoms of a heart attack*." Women often experience different sets of symptoms, but many are symptoms common to both men and women).[41] We also excluded from analysis two items that had a mean difficulty score (% participants answering correctly) of .06 or below or .94 or above. The remaining 71 items were divided among each knowledge domain as follows: dietary knowledge ($N = 16$), epidemiology knowledge ($N = 8$), medical knowledge ($N = 22$), risk factors ($N = 17$), and symptoms ($N = 8$). Within any one domain, less than 2% of data was missing. Participants' answers were coded either 0 = incorrect answer or "I don't know" and 1 = correct answer for each item on the scale.

The data from the 594 participants who answered at least 68 of the 71 items (95%) as well as all 3 items about self-perceived knowledge were analyzed. The overall scale score was calculated as the sum of the correct answers, with percentage score derived by dividing each score by 71. We used list-wise deletion for missing values.

Analysis plan. The main purposes of Phase I analyses were to evaluate the factor structure of the questionnaire and item reduction. Our goal was to produce a questionnaire that contained a reduced number of items, but retained the breadth of domains regarding heart disease knowledge.

SPSS Version 17 was used to obtain descriptive statistics on the overall score of the questionnaire and the three items that measured self-perceived degree of knowledge. Upon item reduction (explained below), the correlation between the participants' overall scores and scores on each of the three perception items was calculated.

The statistical software data analysis program MPlus Version 5.21 ran the confirmatory and exploratory factor analyses, given its ability to model items with dichotomous response format. Two confirmatory factor analyses (CFA) were conducted; a five-factor solution reflecting the theoretical structure of the questionnaire and a one-factor solution representing all items as measuring a general knowledge of heart disease. To assess model fit Comparative Fit Index (CFI),[42] Tucker-Lewis Index (TLI),[43] and Root Mean Square Error of Approximation (RMSEA) were reported.[44] We attempted to identify sources for misfit if the CFA model did not fit one or more of the model fit criteria (i.e., CFI > .95, TLI >. 95, RMSEA <. 05). For example, we examined the model modification indices to identify items that loaded on more than one domain. An exploratory factor analysis (EFA) was also conducted to look for the number of factors and patterns represented in the observed data by examining both the magnitude of the eigenvalues and interpretability of the data associated with each extracted factor.

After comparison of the alternative one- and five-factor models, item reduction began by considering the difficulty of the items (assessed by looking at mean scores), and the discrimination of the items (assessed by looking at factor loadings and item-total score correlations), inter-item correlations (not reported in text; please contact corresponding author for them), and contribution of each item's content towards overall knowledge were taken into consideration when selecting items for the questionnaire. For difficulty, we wanted to ensure that we had items that tapped into different levels of heart disease knowledge; this guarantees that we could discriminate amongst individuals who may have limited knowledge from those who have advanced knowledge. For discrimination, we wanted items that were related to the overall construct of heart disease knowledge to maximize our ability to differentiate among individuals at different skill/knowledge levels.

In some cases, an item with a low factor loading was retained upon having been deemed to measure a key concept not reflected in other questions. We also took into consideration mean scores reflected in our data to ensure the finalized questionnaire had a broad enough range of difficulty to assess different knowledge levels.

Phase II Questionnaire

Instrument description. This instrument was a revised version of the Phase I questionnaire. The updated scale excluded 8 items from Phase I that were no longer accurate based on new findings in the medical literature. The item that was discarded for analysis in Phase I due to ambiguity was rewritten and included in the Phase II questionnaire, as were the 2 items which had been excluded from analysis due to having had poor item-difficulty scores. The resulting scale consisted of 74 items. Participants also completed 11 items from the CVD Knowledge Test[26] (3 items from this 14-item scale were already included in the scale), 3 items that measured self-perceived degree of knowledge about heart disease (the same items from Phase I), and 7 items that measured health behaviors to see if there

was a relationship between health behavior status and heart disease knowledge level. A final item measured participants' perceived health literacy using a conventional 1 item scale, "How confident are you filling out medical forms by yourself?"[33] Participants also reported age and gender.

Participants. Participants were 248 University of Pittsburgh undergraduates enrolled in an introductory psychology course. Participants were 50.4 % male with a mean age of 18.68 (SD = 1.08, range = 17 to 27). Participation fulfilled a course requirement.

Procedure. Participants completed the scale as part of a larger questionnaire in an unrelated research study. Participants scheduled individual appointments with an undergraduate research assistant and completed the questionnaire privately on a computer in the laboratory. The session lasted about one hour. The instructions for the Phase II questionnaire were identical to those of Phase I.

Data preparation. From the original 74 items, three items had mean difficulty scores higher than .94 and were discarded from analyses. Participants' item answers were coded either 0 = incorrect answer or "I don't know" and 1 = correct answer. The scores of 242 participants were used for analyses after excluding participants who did not answer all the items in the questionnaire, answer the 10 items about health behaviors and perceptions, or those from the 14-item CVD Knowledge Test.[26] The overall heart disease scale score was calculated by two different methods. We did these two analyses to show that the five domains are equally important to the total knowledge score. In Method I, the number of correct answers was counted and divided by the final number of items that resulted from the item reduction process (see below). In Method II, we calculated the overall score by taking the sum of the correct answers in each domain, dividing this number (correct items) by the total number of items in the domain. The result of this process gave us five percents (one for each domain), which were added together to give a total scale score ranging from 0 to 5. We expect that the results should be the same from these two different calculation methods.

Analysis plan. The goal of Phase II was to validate the reduced item questionnaire resulting from Phase I and to validate the finalized questionnaire with other heart disease measures.

SPSS Version 17 was used to obtain descriptive statistics on the reduced heart disease knowledge questionnaire, the 10 items about health behaviors and perceptions, and the 14-item CVD Knowledge Test.[26] We obtained internal reliability estimates (coefficient alpha) of the finalized scale (obtained through item reduction), the five knowledge domains as well as correlations among the scale scores. The Kuder-Richardson formula 20 for the internal reliability estimates was reported because our heart disease knowledge scale is dichotomous (true/false).[46] The correlations between the overall scale score on the heart disease knowledge questionnaire and participants' responses to the health literacy item were also calculated.

The statistical software analysis program MPlus Version 5.21 was used to conduct the confirmatory factor analysis on the same five-domain reduced questionnaire. To assess model fit we reported the same fit statistics as in Phase I.

RESULTS

Phase I Questionnaire

Descriptive statistics. For the 71-item scale, the average score was 35.80 with a standard deviation of 8.87 and a range of 0 to 58. Fifty-four percent of participants answered 36 or more of the items correctly. The item mean difficulty ranged from .13 to .93.

Factor analyses. The one-factor confirmatory factor analysis (CFA) solution had fit statistics of CFI = .76, TLI = .79, RMSEA = .04. The five-factor CFA solution had the same results of CFI = .76, TLI = .79, and RMSEA = .04. Given that neither model fit, we explored the modification indices. We found no modification in item loadings that would significantly improve model fit (all changes in χ^2 were less than 4).

An examination of the eigenvalues from an exploratory factor analysis (EFA) of the 71 items revealed at least five factors. The first factor accounted for 15% of the total variance. Factors 1 through 5 accounted for 32% of the total variance. Because the sixth and seventh factors only accounted for a small amount of variance, 3% each, and did not provide additional interpretive solutions, we retained the five-factor model. The five-factor EFA model had good fit statistics with CFI = .96, TLI = .97, and RMSEA = .02.

Based on the factor loadings of the 71-item five-domain model CFA, 38 items loaded well onto one of the domains (factor loadings $\geq .40$). From these 38 items, we discarded 17 items due to their difficulty mean (too easy or too difficult) and content (items' topics were addressed in other items). For the 33 items that did not load well, we reviewed their content and mean difficulty level, and ultimately opted to retain 8 of these items, as their mean difficulties fell within the desired range and their content was deemed to be worthy of inclusion in the questionnaire. The item reduction of Phase I's questionnaire produced 29 items. In sum, criteria used to get from 71 to 29 items were factor loadings, item content area, and difficulty mean.

Descriptive statistics: 29-item scale. The average score for the 29-item scale was 15.77 with a standard deviation of 4.81 and a range of 0 to 28. Sixty-one percent of participants answered 15 or more of the items correctly. The item difficulty mean ranged from .18 to .79. Correlations between the domains for the 29 items were low to moderate (Table 2).

The 29-item questionnaire showed statistically significant associations with 3 items about self-perceived knowledge regarding heart disease: "I know more than the average person about heart disease," $r(592) = .24$, $P < 0.01$; "I believe that I answered 75% or more of the above questions correctly," ($r(592) = .25$, $P < 0.01$); and "I believe that I answered more of the above questions correctly than the average person will," ($r(592) = .37$, $P < 0.01$). In other words, people who performed better on the scale tended

Table 2. Correlations Among the 5 Knowledge Domains (29 items)

Variables	Dietary	Epidemiology	Medical	Risk Factor	Symptoms
Dietary	-	.25	.37	.38	.25
Epidemiology		-	.31	.47	.27
Medical			-	.42	.31
Risk Factor				-	.33
Symptoms					-

Note: All correlations significant at $P < .001$.

to rate their performance more highly, although the moderate magnitude of these correlations suggests a fair degree of error in self-perceived knowledge.

Phase II Questionnaire

Descriptive analyses. By Method I calculations (see Methods-Phase II section), the mean scale score for the 30-item scale (29 items from Phase I, plus 1 rewritten item with the addition of "many of," "Men and women experience *many of* the same symptoms of a heart attack," to improve clarity and included in the Phase II questionnaire) was 15.68 with a standard deviation of 4.71 and a range of 2 to 25. Sixty-three percent of participants answered 15 or more of the items correctly. By Method II calculations, the mean scale score for the 30-item scale was 2.61 with a standard deviation of .80 and a range of .39 to 4.33. Because the 30-item scale was divisible by the scale score range of 5, these percentage scores were multiplied by 6, so that Method I and Method II final scale scores could be compared. Method II's converted mean scale score was 15.67 with a standard deviation of 4.79 and a range of 2.36 to 25.95. The item mean difficulty ranged from .18 to .75. The Kuder-Richardson 20 formula for the 30-item scale was acceptable (.73), but was not for the five individual knowledge domains (range = .29 to .47).

The mean scale score for the 10 items about health behaviors and perceptions was 3.88 with a standard deviation of 1.57 and a range of 0 to 9. Approximately 59% of participants answered 4 or more items correctly. The mean scale score for the 14-item CVD Knowledge Test[26] was 7.70 with a standard deviation of 1.59 and a range of 2 to 12. Eighty percent of participants answered 7 or more items correctly.

The 30-item questionnaire showed statistically significant associations with the 3 items about self-perceived knowledge about heart disease (out of the 10 items about health behaviors and perceptions): "I know more than the average person about heart disease," $r(240) = .33$, $P < 0.01$; "I believe that I answered 75% or more of the above questions correctly," $r(240) = .18$, $P < 0.01$; and "I believe that I answered more of the above questions correctly than the average person will," $r(240) = .39$, $P < 0.01$). Scores were also positively correlated with the item, "I know my blood pressure level," $r(240) = .15$, $P < 0.05$. The correlation between the 30 items and the 14-item CVD Knowledge Test[26] was moderately positive, $r(240) = .59$, $P < 0.01$, suggesting both convergent and divergent validity. The correlation between the 30 items and the health literacy item was weakly positive, $r(240) = .32$, $P < 0.01$, suggesting divergent validity.

Factor analyses. The five-factor confirmatory factor analysis (CFA) solution produced model fit statistics of CFI = .82, TLI = .88, and RMSEA = .03. Table 3 summarizes both the mean (difficulty) and factor loading (discrimination ability) of each item in each knowledge domain for the five-factor CFA. Appendix 1 presents the final 30-item heart disease knowledge questionnaire and includes the item content, the correct answer, and the mean difficulty.

Ad hoc panel. An ad hoc panel reviewed our final 30-item scale and revisions were done based on their feedback (Appendix 1). The panel suggested rewording three items, "*Taking an aspirin each day is thought to decrease the risk of getting heart disease*" to "*Taking an aspirin each day decreases the risk of getting heart disease,*" "*The best kind of exercise involves rapid breathing for a sustained period of time*" to "*The healthiest kind of exercise for the heart involves rapid breathing for a sustained period of time,*" and "*Turning pale or gray is a common symptom of having heart attack*" to "*Turning pale or gray is a symptom of having heart attack.*" Rewording the items did not change the correct response answer, nor do we think it influenced the results before the change.

DISCUSSION

This paper describes the development of a novel heart disease knowledge questionnaire through two phases. The purpose of Phase I was to validate the five-factor model and perform item reduction. The result was a 29-item questionnaire. The purpose of Phase II was to validate the final 30-item questionnaire (29 items from Phase I along with an item that was rewritten and reintroduced). We also evaluated the extent to which participants accurately discerned the scope of their heart disease knowledge in both phases, and validated the new scale by correlating it with an existing but dated measure of heart disease knowledge,[26] as well as with a conventional measure of health literacy.[33]

Table 3. Standardized Model Results—Factor Loadings of the 5 Knowledge Domains (30 items)

Items	Dietary (*N* = 6)	Epidemiology (*N* = 4)	Medical (*N* = 7)	Risk Factors (*N* = 9)	Symptoms (*N* = 4)	Difficulty Mean
Polyunsaturated fats are healthier for the heart than saturated fats.	28					63
Trans-fats are healthier for the heart than most other kinds of fats.	.49					.66
Most of the cholesterol in an egg is in the white part of the egg.	.56					.65
Dietary fiber lowers blood cholesterol.	.44					.48
Margarine with liquid safflower oil is healthier than margarine with hydrogenated soy oil.	.29					.38
Many vegetables are high in cholesterol.	.29					.71
Women are less likely to get heart disease after menopause than before.		.54				.34
Heart disease is the leading cause of death in the United States.		.44				.60
Most women are more likely to die from breast cancer than heart disease.		.61				.38
Heart disease is better defined as a short-term illness than a chronic, long-term illness.		.56				.70
Most people can tell whether or not they have high blood pressure.			.51			.72
The best kind of exercise involves rapid breathing for a sustained period of time.			.29			.38
A healthy person's pulse should return to normal within 15 minutes after exercise.			.41			.73
Cardiopulmonary resuscitation (CPR) helps to clear clogged blood vessels.			.42			.65
HDL refers to "good" cholesterol, and LDL refers to "bad" cholesterol.			.12			.31
Atrial defibrillation is a procedure where hardened arteries are opened to increase blood flow.			.48			.19
"High" blood pressure is defined as 110/80 (systolic/diastolic) or higher.			.37			.26
Having had chicken pox increases the risk of getting heart disease.				.36		.52
Eating a lot of red meat increases heart disease risk.				.20		.65
The most important cause of heart attacks is stress.				.45		.34
Walking and gardening are considered types of exercise that can lower heart disease risk.				.54		.75

Continues on next page

Table 3. Standardized Model Results—Factor Loadings of the 5 Knowledge Domains (30 items) (Con't)

Items	Dietary (*N* = 6)	Epidemiology (*N* = 4)	Medical (*N* = 7)	Risk Factors (*N* = 9)	Symptoms (*N* = 4)	Difficulty Mean
Smokers are more likely to die of lung cancer than heart disease.				.44		.23
Taking an aspirin each day is thought to decrease the risk of getting heart disease.				.44		.70
Taller people are more at risk for getting heart disease.				.36		.38
People who have diabetes are at higher risk of getting heart disease.				.43		.64
Eating a high fiber diet increases the risk of getting heart disease.				.41		.60
Turning pale or gray is a common symptom of having heart attack.					.44	.51
Sudden trouble seeing in one eye is a common symptom of having a heart attack.					.47	.18
Feeling weak, lightheaded, or faint is a common symptom of having a heart attack.					.58	.71
Men and women experience many of the same symptoms of a heart attack.					.26	.70

Note: Standardized model results; STDYX Standardization

Phase I Questionnaire

The majority of the participants answered at least half of the items correctly for both the 71 and 29-item scales. Only about a quarter of the participants answered 2 or more of the 4 items about self-perceived knowledge in such a way as to reflect confidence in their knowledge of heart disease, both absolutely and in comparison to the average person. The item difficulty means of the 29 items fell within an appropriate range, with 11 items having a difficulty mean of .40 to .60. The average difficulty mean for the 29 items was .54. Scales with difficulty means that are close to .50 give a more accurate assessment of an individual's knowledge level because they provide "maximum discrimination"[46] in individuals' degree of heart disease knowledge.

The CFA and EFA conducted on the 71 items produced a reduced 29-item scale. Although the CFA produced mixed fit statistics for our model, the EFA validated the decision that the five-factor model was a good choice for our 71-item scale. The correlations among the 5 knowledge domains for the 29 items were low to moderate, all positive and significant. These correlations indicate that the content information in each domain did not overlap, but that all domains were indeed measuring heart disease knowledge.

The correlation between the 29-item heart disease knowledge questionnaire and the 3 items assessing self-perceived knowledge was statistically significant, though moderate. Thus, people who know more are also generally more aware that they know more, but there is still a fair degree of error in these self-assessments.

Phase II Questionnaire

Both methods for calculating the overall score for the 30-item scale produced similar results. As with Phase I, the majority of participants answered at least half of the items correctly for the 30-item questionnaire. A majority of participants answered at least 4 items on the 10-item scale about perceptions and health behaviors and at least 7 items correctly on the 14-item CVD Knowledge Test.[26] The level of difficulty was appropriate.

The low alpha levels of the five knowledge domains suggest that while looking at how participants perform on each subscale of heart disease knowledge is informative, it cannot be considered a reliable scale for assessing group differences or changes over time. However, the overall 30-item scale had an acceptable internal reliability[47] of .73 for examining group level scores on heart disease knowledge.

The correlation between the 30-item scale and 14-item CVD Knowledge Test[26] was moderately positive (.59) which supports our assumptions that our current scale and the previous scale showed both convergent and divergent validity. It is evidence of convergent validity because it is associated with another scale tapping into

Appendix 1. Heart Disease Knowledge Questionnaire

Instructions:

On the following page, you will be asked to respond to a number of True/False questions addressing your beliefs and knowledge about various aspects of heart disease.
Please answer each by circling "T" for True and "F" for False.
Very few people answer all these questions correctly—just do the best you can. Feel free to circle 'Don't know' if you are unsure of an answer.

EXAMPLE:

High blood pressure increases the risk of getting heart disease……(T) F Don't know

Item	Item Content	Correct Response	Difficulty Mean
HD1	Polyunsaturated fats are healthier for the heart than saturated fats.	True	.63
HD2	Women are less likely to get heart disease after menopause than before.	False	.34
HD3	Having had chicken pox increases the risk of getting heart disease.	False	.52
HD4	Eating a lot of red meat increases heart disease risk.	True	.65
HD5	Most people can tell whether or not they have high blood pressure.	False	.72
HD6	Trans-fats are healthier for the heart than most other kinds of fats.	False	.66
HD7	The most important cause of heart attacks is stress.	False	.34
HD8	Walking and gardening are considered types of exercise that can lower heart disease risk.	True	.75
HD9	Most of the cholesterol in an egg is in the white part of the egg.	False	.65
HD10	Smokers are more likely to die of lung cancer than heart disease.	False	.23
HD11	Taking an aspirin each day decreases the risk of getting heart disease.	True	.70
HD12	Dietary fiber lowers blood cholesterol.	True	.48
HD13	Heart disease is the leading cause of death in the United States.	True	.60
HD14	The healthiest exercise for the heart involves rapid breathing for a sustained period of time.	True	.38
HD15	Turning pale or gray is a symptom of having a heart attack.	True	.51
HD16	A healthy person's pulse should return to normal within 15 minutes after exercise.	True	.73
HD17	Sudden trouble seeing in one eye is a common symptom of having a heart attack.	False	.18
HD18	Cardiopulmonary resuscitation (CPR) helps to clear clogged blood vessels.	False	.65
HD19	HDL refers to "good" cholesterol, and LDL refers to "bad" cholesterol.	True	.31
HD20	Atrial defibrillation is a procedure where hardened arteries are opened to increase blood flow.	False	.19
HD21	Feeling weak, lightheaded, or faint is a common symptom of having a heart attack.	True	.71
HD22	Taller people are more at risk for getting heart disease.	False	.38
HD23	"High" blood pressure is defined as 110/80 (systolic/diastolic) or higher.	False	.26
HD24	Most women are more likely to die from breast cancer than heart disease.	False	.38
HD25	Margarine with liquid safflower oil is healthier than margarine with hydrogenated soy oil.	True	.38
HD26	People who have diabetes are at higher risk of getting heart disease.	True	.64
HD27	Men and women experience many of the same symptoms of a heart attack	True	.70
HD28	Eating a high fiber diet increases the risk of getting heart disease.	False	.60
HD29	Heart disease is better defined as a short-term illness than a chronic, long-term illness.	False	.70
HD30	Many vegetables are high in cholesterol.	False	.71

Note: Items HD4 and HD28 overlap with both dietary and risk factor domains. However, we kept them in the risk factor domain because they refer to a particular dietary risk factor of heart disease, as opposed to general dietary aspects pertaining to overall heart health, which are in the dietary domain.

similar heart disease knowledge. However, it also can be said that there is unique information contained in our current scale as it only has about 36% shared variance with the other scale. Finally, the correlation between the 30-item scale and the 1 item about health literacy was weakly positive. The correlation between the 30-item scale and the item about knowledge of blood pressure level was found to be significant, though low, suggesting that people who are aware of their medical status are not necessarily more knowledgeable about heart disease in general. This suggests divergent validity because the 1 item measure of health literacy cannot adequately measure knowledge in a given area of health knowledge and that participants were often inaccurate in their judgments of their heart disease knowledge.

Although the five-factor CFA model fell below the good fit criteria of CFI and TLI, the loadings were relatively good. Twenty-one of the items had factor loadings above .40, which shows that the items loaded well onto their pre-established factors.

Limitations

One limitation of the current study is the use of a university student sample. Depending on individual circumstances, heart disease may not be a relevant issue for this particular population; thus, they may be less educated about it than an older population. To determine if there was a difference in knowledge level based on age and years of education, we compared the 30-item overall scale scores between the current Phase II sample ($N = 242$) to a sample of adults. Participants were 27 adults from the Pittsburgh community who had completed the heart disease knowledge questionnaire as part of another study. The participants were 66.7% female with a mean age of 56.93 (SD = 9.62, range = 40 to 79). For the adult sample, the mean 30-item scale score was 12.56 with a standard deviation of 3.84 and a range of 4 to 18 (as compared with the college sample, M = 15.68, SD = 4.71, range = 2 to 25).

The correlations between the overall score and age, and the overall scale score and years of education were calculated. The correlation between the overall score and age was weakly negative, but statistically significant, $r(267) = -.17$, $P < 0.01$. There was no correlation between overall score and years of education, $r(264) = -.03$, $P > 0.05$. Overall, these findings argue against the concern that the young age of the sample was problematic.

In addition, neither the Phase I nor Phase II samples were asked to specify race/ethnicity. This makes it impossible to examine the results for differences in levels of knowledge among those of varying racial/ethnic groups. Future studies are needed to determine whether the results of the current study can be generalized to other population samples, and to explore the impact of individuals' race or ethnicity on level of heart disease knowledge.

The different methods used in Phase I and Phase II to administer the heart disease questionnaire is a possible limitation. In Phase I the questionnaire was completed as part of a mass testing session, but in Phase II the questionnaire was completed privately on a computer. It is possible that there may be potential method effects from this difference. However, a reliable and valid questionnaire should be able to be used in multiple contexts.

Another limitation is the manner in which we chose to reduce items in Phase I analyses. It is possible that through discarding items based on their content validity we removed items that might in fact be important to the overall construct of heart disease knowledge, though in the present study met all criteria for removal.

A final limitation is that the variance from the Phase I, 71-item EFA only accounted for about 30% of the total variance. One reason for this low variance is that we were only interested in the participants' overall scores as opposed to the profile scores of the individual knowledge domains. Both the overall score and the profile score have their benefits. The overall score may account for a lower variance, but this score can help to develop heart disease prevention education policy because the overall score provides a single score that can be used to compare different samples. On the other hand, the profile score may produce better variance, but can only help to develop tailored interventions for that specific individual based on how they did on each domain. We recommend that further researchers look at both the overall score and profile score to determine a more accurate assessment of a scale's variance. Doing this may also help to shape broad policy changes, as well as tailored individual interventions in the field of heart disease prevention education.

Heart disease is the number one killer of both men and women in the United States. Knowledge of risk factors, symptoms, and epidemiology of heart disease is essential to prevention, identification, and appropriate action, yet a comprehensive and evidence-based knowledge assessment is currently not available. This current study met this need by developing a heart disease knowledge questionnaire. Overall, the results indicate that the resulting 30-item questionnaire designed to measure heart disease knowledge, as conceptualized across five key domains, exhibited sound psychometric properties.

Designed to be easily administered, this scale could serve as a valuable tool to researchers and practitioners alike. By including items with a wide range of difficulties, it possesses maximum power to discriminate across the spectrum of knowledge levels, and could likewise be useful in the identification of knowledge gaps at an individual level, so as to inform tailoring of health information. It is also more comprehensive than any existing scale in that it measures knowledge of heart disease etiology, epidemiology and symptomatology and can be used with most adult samples.

One interesting finding is that participants' perceived knowledge was somewhat incongruent with their actual knowledge. Studies in such areas as condom-use behavior[48,49] and food-related hazards[50] have shown that people who rate their perceived knowledge as high often actually have low levels of actual knowledge. Thus, it is particularly essential to use actual scales to measure heart disease knowledge rather than to rely on self-reports.

One of the primary challenges of questionnaire development is to ensure that the essential aspects of a particular construct are captured, and we believe that the items in the current questionnaire do indeed address the central elements of heart disease knowledge. We considered many criteria in order to determine item reduction including factor loadings, reliability, items' content areas, and a review by an ad hoc panel of the resulting scale items. This allowed us to ensure that the scale's ultimate content was sufficiently reflective of each important knowledge domain.

TRANSLATION TO HEALTH EDUCATION PRACTICE

Findings from this study are consistent with the growing heart disease literature, describing a gap between perceived and actual knowledge of heart disease.[28,30,51-53] For example, the low correlation between the one item addressing medical status and the 30-item overall scale score suggests that awareness of personal health biomarkers, such as blood pressure, is not reliably associated with breadth of knowledge about the causes, symptoms and other attributes of heart disease. In addition, the weak correlation between the measure of health literacy and the 30-item overall scale score indicates that variation in knowledge about heart disease cannot be accounted for simply by differences in health literacy.

The current scale could be used by health professionals such as cardiologists, primary care providers, and health educators to tailor educational programs to the knowledge base of their individual patients. These programs would help meet the needs of patients by helping to bridge gaps between perceived and actual knowledge of heart disease. Benefits of tailored education materials include an increased likelihood that individuals will have read the information,[55,56] remembered it,[55,56] and will find it personally relevant.[55] Moreover, tailored health education/information has been shown to reduce health literacy disparities[57] and works well in the context of other intervention programs.[55] Tailored programs could ensure that individuals are not only becoming more knowledgeable about heart disease, but that they know which specific behaviors and actions they can take to reduce their risk, such as changing diet, increasing amount of physical activity, and being aware of signs and symptoms of a heart attack.

The goal of having individuals complete this scale and review their score with a health educator is that if individuals know their heart disease knowledge score, are aware of their knowledge gaps, and understand the differences between their perceived and actual knowledge, then they will be more likely to apply their increased heart disease knowledge to behavior change. Although increased knowledge does not always lead to behavior change,[52,54] a review of tailored print communications studies showed that individualized tailored information can lead to positive behavioral change.[55] Tailored health education programs that address heart disease knowledge gaps have the potential to lead to change in areas such as nutrition, exercise, and smoking,[55] all risk factors for heart disease. The tailored education programs, in conjunction with other intervention programs, may lead to more effective and efficient patient care for those at risk of heart disease.

ACKNOWLEDGEMENTS

The authors would like to thank the three ad hoc panel members Denise Bonds, MD, MPH, Jerry Suls, PhD, and Gordon Willis, PhD, Michael Sanchez, MPH, CHES, and Dikla Shmueli, PhD, for their contributions in preparation of this manuscript.

REFERENCES

1. Centers for Disease Control and Prevention. Leading Causes of Death 1900-1998. Available at: http://www.cdc.gov/nchs/nvss/mortality_historical_data.htm. Accessed February 16, 2010.

2. Centers for Disease Control and Prevention. Prevalence of heart disease—United States, 2005. *MMWR Weekly* [serial online] February 2007:56 (6):113-118. Available from: Centers for Disease Control and Prevention, Atlanta, Ga. Accessed February 16, 2010.

3. Lloyd-Jones DM, Adams R, Carethon M, et al. Heart disease and stroke statistics—2009 update: a report from the American heart association statistics committee and stroke statistics committee. *Cirulation*. 2009;119:e21-e181.

4. Lloyd-Jones DM, Laron MG, Beiser A, et al. Lifetime risk of developing coronary heart disease. *Lancet*. 1999;353: 89-92.

5. Mokdad AH, Marks JS, Stroup DF, et al. Actual causes of death in the United States, 2000. *JAMA*. 2004;291:1238-1245.

6. American Heart Association. Heart Disease and Stroke Statistics: Our Guide to Current Statistics and the Supplement to Our Heart & Stroke Facts—2010 Update At-a-Glance. Available at: http://www.americanheart.org/presenter.jhtml?identifier=3000090. Accessed February 16, 2010.

7. Goff DC, Sellers DE, McGovern PG, et al. Knowledge of heart attack symptoms in a population survey in the United States. *JAMA*.1998;158:2329-2338.

8. Johnston TC, Clark MJ, Dingle GA, et al. Levels of cardiac knowledge and cardiopulmonary resuscitation training among older people in Queensland. *Australas J Ageing*. 2004;23:91-96.

9. Liew H, Taylor D, Tjipto A, et al. Investigation of the variables that impact upon the knowledge of cardiac risk factors. *Emergen Med Australas*. 2006;18:252-258.

10. Lynch EB, Liu K, Kiefe CI, et al. Cardiovascular disease risk factor knowledge in young adults and 10-year change in risk factors. *Am J Epidemiol*, 2006;164:1171-1179.

11. Prendergast HM, Bunney EB, Roberson T, et al. Knowledge of heart disease among women in an urban emergency setting. *J Natl Med Assoc.* 2004;96:1027-1031.

12. Cameron JD, Jennings GL, Kay S, et al. A self-administered questionnaire for detection of unrecognised coronary heart disease. *Aust Nz J Publ Heal.* 1997;21:545-547.

13. Lanhenhoven ML, Rossouw JE, Jooste PL, et al. Change in knowledge in a coronary heart disease risk factor intervention study in three communities. *Soc Sci Med.* 1991;33:71-76.

14. White CW, Albanese MA. Changes in cardiovascular health knowledge occurring from childhood to adulthood. *Circulation.* 1981;63:1110-1114.

15. Collins KM, Dantico M, Shearer NBC, et al. Heart disease awareness among college students. *J Commun Health.* 2004;29:405-420.

16. DeForge BR, Steward DL, DeVoe-Weston M, et al. The relationship between health status and blood pressure in urban African Americans. *J Natl Med Assoc.* 1998;90:658-664.

17. John H, Treharne G, Hale E, et al. Development and initial validation of a heart disease knowledge questionnaire for people with rheumatoid arthritis. *Patient Educ Couns.* 2009;77:136-143.

18. Momtahan K, Berkman J, Sellick J, et al. Patients' understanding of cardiac risk factors: a point-prevalence study. *J Cardiovasc Nurs.* 2004;19:13-20.

19. Tate J, Cade J. Public knowledge of dietary fat and coronary heart disease. *Health Educ J.* 1990;49:32-35.

20. Thanavaro JL, Thanavaro S, Delicath T. Coronary heart disease knowledge tool for women. *J Am Acad Nurse Pract.* 2010;22:62-69.

21. Wagner J, Abbott G, Lacey K. Knowledge of heart disease among Spanish speakers with diabetes: the role of interpreters in the medical encounter. *Ethn Dis.* 2005a;15:679-684.

22. Wagner J, Lacey K, Chyun D, et al. Development of a questionnaire to measure heart disease risk knowledge in people with diabetes: the heart disease fact questionnaire. *Patient Educ Couns.* 2005b;58:82-87.

23. Smith MM, Hicks VL, Heyward VH. Coronary heart disease knowledge test: developing valid and reliable tool. *Nurse Pract.* 1991;16:28,31,35-8.

24. Farquhar JW, Fortmann SP, Flora JA, et al. Effects of communitywide education on cardiovascular disease risk factors: the Stanford five-city project. *JAMA.* 1990;264:359-365.

25. Thanavaro JL, Moore SM, Anthony MK, et al. Predictors of poor coronary heart disease knowledge level in women without prior coronary heart disease. *J Am Acad Nurse Pract.* 2006;18:574-581.

26. Suminski RR, Anding J, Smoth D, et al. Risk and reality: the association between cardiovascular disease risk factor knowledge and selected risk-reducing behaviors. *Fam Community Health.* 1999;21:51-62.

27. Folsom AR, Sprafka JM, Luepker RV, et al. Beliefs among black and white adults about causes and prevention of cardiovascular disease: the Minnesota heart survey. *Am J Prev Med.* 1988;4:121-127.

28. Mosca L, Jones WK, King KB, et al. Awareness, perception, and knowledge of heart disease risk and prevention among women in the United States. *Arch Fam Med.* 2000;9:506-515.

29. Oliver-McNeil S, Artinian NT. Women's perceptions of personal cardiovascular risk and their risk-reducing behaviors. *Am J Crit Care.* 2002;11:221-227.

30. Mosca L, Ferris A, Fabunmi R, et al. Tracking women's awareness of heart disease an American heart association national study. *Circulation.* 2004;109:573-579.

31. Baker D, Parker R, Williams M, et al. The health care experience of patients with low literacy. *Arch Fam Med.*1996;5:329-334.

32. Poe GS, Seeman I, McLaughlin J, et al. "Don't know" boxes in factual questions in a mail questionnaire: effects on level and quality of response. *Public Opin Quart.* 1988;52:212-222.

33. Chew LD, Bradley KA, Boyko EJ. Brief questions to identify patients with inadequate health literacy. *Fam Med.* 2004;36:588-594.

34. Leventhal H. Findings and theory in the study of fear communications. In Berkowitz L, ed. Advances in Experimental Social Psychology. New York: Academic; 1970:119-186.

35. Leventhal H, Diefenbach M. (1991). The active side of illness cognition. In Skelton JA, Croyle RT, eds. Mental Representations in Health and Illness. New York: Springer-Verlag; 1991:247-272.

36. Leventhal H, Nerenz DR, Steele DJ. Illness representations and coping with health threats. In: Baum A, Singer J ed. A Handbook of Psychology and Health. Hillsdale, NJ: Erlbaum Associates; 1984:219 - 252.

37. Cameron LD, Leventhal H. Vulnerability beliefs, symptom experiences, and the processing of health threat information: a self-regulatory perspective. *J Appl Soc Psychol.* 1995;25:1859-1883.

38. Maes S, Karoly P. Self-regulation assessment and intervention in physical health and illness: a review. *Appl Psychol-Int Rev.* 2005;54:267-299.

39. Cameron L, Leventhal E, Leventhal K. Symptom representations and affect as determinants of care seeking in a community-dwelling, adult sample population. *Health Psychol.* 1993;12:171-179.

40. National Institute of Diabetes and Digestive Kidney Diseases. Understanding Adult Obesity. Available from: http://www.win.niddk.nih.gov/publications/understanding.htm. Accessed July 9, 2010.

41. Meischke H, Larsen MP, Eisenberg MS. Gender differences in reported symptoms for acute myocardial infarction: impact on prehospital delay time interval. *Am J Emerg Med.* 1988;16:363-366.

42. Bentler PM. Comparative fit indexes in structural models. *Psychol Bull.* 1990;107:238-246.

43. Tucker RL, Lewis C. A reliability coefficient for maximum likelihood factor analysis. *Psychometrika.* 1973;38:1-10.

44. Hu L, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Struct Equ Modeling.* 1999;6:1-55.

45. Cronbach L. Coefficient alpha and the internal structure of tests. *Psychometrika.* 1951;16:297-334.

46. Gronlund NE. How to Construct Achievement Tests, 4th ed. Englewood Cliffs, NJ: Prentice-Hall; 1988.

47. De Vellis RF. Scale development: theories and applications. 2nd ed. Sage; 2003.

48. Crosby RA, Yarber WL. Perceived versus actual knowledge about correct condom use among U.S. adolescents: results from a national study. *J Adolescent Health.* 2001;28:415-420.

49. Rock EM, Ireland M, Resnick MD, et al. A rose by any other name? objective knowledge, perceived knowledge, and adolescent male condom use. *Pediatrics.* 2005;115:667-672.

50. Frewer LJ, Shepherd R, Sparks P. The interrelationship between perceived knowledge, control and risk associated with a range of food-related hazards targeted at the individual, other people and society. *J Food Safety.* 1993;14:19-40.

51. Niknian M, McKinlay SM, Rakowski W,

Carleton RA. A comparison of perceived and objective CVD risk in a general population. *Public Health Briefs.* 1989;79:1653-1654.

52. Wilcox S, Stefanick ML. Knowledge and percieved risk of major diseases in middle-aged and older women. *Health Psychol.* 1999;18:346-353.

53. Frijling BD, Lobo CM, Keus IM, et al. Perceptions of cardiovascular risk among patients with hypertension or diabetes. *Patient Educ Couns.* 2004;52:47-53.

54. Serdula MK, Gillespie C, Kettel-Khan L, et al. Trends in fruit and vegetable consumption among adults in the United States: behavioral risk factor surveillance system, 1994-2000. *Am J Public Health.* 2004;94:1014-1018.

55. Skinner CS, Campbell MK, Rimer BK, et al. How effective is tailored print communication? *Ann Behav Med.* 1999;21:290-298.

56. Campbell MK, DeVellis BM, Strecher VJ, et al. Improving dietary behavior: the effectiveness of tailored messages in primary care settings. *Am J Public Health.* 1994;84:783-787.

57. Paasche-Orlow MK, Riekert KA, Bilderback A, et al. Tailored education may reduce health literacy disparities in asthma self-management. *Am J Respir Care Med.* 2005;172:980-986.