Research Article

DEVELOPMENT AND PSYCHOMETRIC EVALUATION OF THE HYPERTENSION KNOWLEDGE TEST FOR INDIAN HYPERTENSIVE PATIENTS (HKT-I)

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ABSTRACT

Objective: The objective of the study was to develop and validate a multi-dimensional test for the measurement of hypertension-related knowledge among hypertensive patients.

Methods: Using a two-stage sampling procedure, four villages were randomly selected from a total of 40 villages, and 224 hypertensive patients were randomly sampled from these villages in the Medchal district of Telangana in India.

Results: Exploratory factor analysis using the principal components method, with varimax rotation revealed a five-factor solution viz. Hypertension-related Management and Control, General Knowledge, Lifestyle-related Knowledge, Health Complications, and Risk Factorswhich accounted for 75% of the total variance. The Hypertension Knowledge Test for Indian Hypertensive Patients (HKT-I) comprised of 31 items and the Cronbach's alpha reliability value of the test was found to be .97 for this sample. The criterion-related validity of the HKT-I was established as the HKT-I scores, were significantly positively correlated with the scores of the Hypertension Therapeutic Adherence Scale for Indian hypertensive patients (HTAS-I) ($r = 0.81$, $p < 0.001$), and the Health Beliefs Scale for Hypertensive Patients (HBSHP) ($r = 0.84$, $p < 0.001$) and significantly negatively correlated with the systolic ($r = -0.44$, $p < 0.001$)and diastolic ($r = -0.56$, $p < 0.001$) blood pressure (BP) measurements.

Conclusion: The HKT-I was found to be a reliable and valid multi-dimensional instrument, for the measurement of hypertension-related knowledge, among Indian hypertensive patients. Hence the HKT-I can serve to quantify hypertension-related knowledge holistically, to identify and screen hypertensive patients with low levels of knowledge regarding their condition.

INTRODUCTION

Hypertension is a chronic non-communicable disease condition known as the "silent killer", constituting a huge public health burden in both the developed, and developing countries of the world. Scientific evidence has indicated that more than 1.1 billion people worldwide (45% of the current global disease burden), have hypertension [1,2] with 340 million living in economically developed nations, and 340 million living in economically developing nations[3].The complications of hypertension have been found to account for 57 million disability-adjusted life years (DALYS) and 9.4 million deaths annually which is approximately 15% to 18% of deaths worldwide every year [2,4–6]. The global prevalence of hypertension has been estimated to range between 30% and 45%, with the condition afflicting one in three adults worldwide [7,8], being the third largest cause of disability [6] and increasing the risk of cardiovascular complications by two to three times[9].

The burden of hypertension is increasing worldwide, and it has been estimated that the prevalence of hypertension will increase by 60%, with approximately 1.56 billion affected individuals by the year 2025[10]. Hypertension is a global public health challenge, as it is rapidly increasing in prevalence accounting for morbidity, disability, and mortality from cardiovascular diseases, renal failure, ischemic heart disease, and stroke resulting in a financial drain on health care system, and individual resources [11–13].This raises an alarm for the health care systems and individual families, as the life-threatening impact of untreated and uncontrolled hypertension, can have deleterious health, social and economic costs for

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nations. The World Health Organization (WHO) posits that poor compliance to the treatment regimen, is the most important determinant of uncontrolled blood pressure (BP) levels with 50% to 70% of hypertensive patients, being non-adherent to their prescribed treatment regimen[14],and 75% of patients failing to achieve optimal BP control[15].The rates of uncontrolled hypertension, in developed countries have been found to range between 30% and 40%, and in developing countries have been found to be about 60% to 70% in urban areas and 80% to 90% in rural areas[16].

India known as the "Diabetic Capital of the World", is undergoing a socio-demographic, economic, and epidemiological transition, and is heading towards being recognized as the "Hypertension Capital of the World"[17].India is undergoing a rapid epidemiological transition, with ageing patterns, urbanization, and improvements in the standards of living accompanied by obesity and its associated cardiovascular risk factors, causing an increase in the proportion of disability-adjusted life years attributed to non-communicable diseases, from 31% of the total DALY's in 1990 to 55% in 2016[18].

The management of chronic illnesses such as hypertension, poses a significant public health challenge in resource-limited countries like India, where approximately 70% (700 million) of the Indian population reside in villages [19], and suffer from the constraints of paucity of health facilities, untrained health care providers and unaffordability of anti-hypertensive medications and medical care[20].

A nationally representative population-based study, conducted among 1.3 million adults from 27 states in India, found the prevalence of hypertension to be 25%, constituting an approximate population burden of 207 million individuals living with the disease[18,21]. A systematic review of population-based epidemiological studies, has found the prevalence of hypertension to be 25% to 30% in urban areas and 10% to 20% in rural India, with the primary determinants of poor hypertension treatment and control being rural residence, low socio-economic status and low educational status[22].

Low levels of treatment adherence in the low-income countries, have been found to be associated with rural residence and low education, reflecting the influence of socio-economic factors on accessibility to health care, knowledge of the complications of uncontrolled hypertension, and the affordability of medical care[16]. Scientific literature has shown that among the urban populations in India, who were aware of their hypertensive status, the treatment and control rates were found to be 38% and 20% respectively, while in the rural populations the treatment and control rates, were found to be 25% and 11% respectively [22]. A systematic review in India, found the prevalence of hypertension in urban and rural South India, to be 33.1% and 28.3% respectively[23].

The rates of awareness, treatment and control of hypertension among hypertensive patients in India have been found to be abysmally low. A systematic review found that among the 33% of the urban and 25% of the rural Indian population who were hypertensive, only 42% of the urban and 25% of the rural population were aware of their hypertensive status, of those aware only 38% of the urban and 25% of the rural

population were receiving treatment for their condition, and one-fifth of the urban and one-tenth of the rural population had their hypertension under control[23].This finding is consistent with the results of a survey conducted by the Cardio logical Society of India, among 1.8 lakh people from 24 states which found that although one-third of the Indian population were afflicted with hypertension, 60% of hypertensive patients were unaware of their hypertensive diagnosis and 42% of those taking anti-hypertensive medication had poor BP control, indicating the urgent need for patient health education among the hypertensive population[24].A recent population-based health survey conducted by the Union Health Ministry, across 100 districts of India among 22.5 million adults found that, although one in every eight individuals had high BP, the majority of hypertensive individuals were unaware of their hypertensive diagnosis[25].

An alarming trend in recent times is that the prevalence of hypertension, is increasing among young adults and children with a majority of individuals in this age-group, having inadequate knowledge regarding the lifestyle and behavioral risk factors for the development of hypertension [26]. A nation-wide population-based survey in India, found that a growing number of young adults were being afflicted with hypertension, with the prevalence of hypertension in the age-group of 18 to 25 years being 12%[18]. A preventive medical screening survey conducted among 980 school going children, in the age range of 5 to 18 years indicated that a significant proportion of children were hypertensive, with the parents of these children being ignorant of their child's hypertensive status [27]. A study conducted among 1611 students in the age group of 17 and 25 years, randomly sampled from two colleges in the Moinabad area in the state of Telangana found, the prevalence of pre-hypertension and hypertension to be 26.95% and 4.86% respectively[28], indicating the urgent need to implement patient health education programs in schools, colleges, workplaces and the IT industry[29].

The barriers to treatment and lifestyle regimen adherence, among rural hypertensive women in India were found to be, poor knowledge regarding the risk factors of hypertension such as high salt and fat intake, sedentary lifestyle patterns, a low priority given to raised blood pressure as compared to other health problems and poor doctor patient communication [30]. Several studies have found that hypertensive patients in rural communities, possess several misconceptions regarding hypertension, leading to the high prevalence of uncontrolled blood pressure among them[31–33].

A sound understanding and knowledge of hypertension, was found to facilitate the early detection, diagnosis, treatment and control of the disease, thus reducing the health, social, and economic costs of the adverse health complications, of undetected and uncontrolled hypertension [34,35]. Scientific evidence has indicated that a failure to achieve optimal blood pressure control, has been attributed to the deficiencies in patients' knowledge, perceptions, attitudes, and lifestyle practices [36–39]. The misconceptions and maladaptive health beliefs of hypertensive patients, were found to negatively impact the knowledge and adherence behaviors of patients, resulting in poor health outcomes [40]. Empirical literature has indicated that comprehensive knowledge about hypertension, the behavioral risk factors, causes and course of hypertension,

the critical role of lifestyle changes and the reasons for anti-hypertensive medication were found to be important determinants of hypertension prevention, medication adherence, positive health behaviors, lifestyle modifications, control of raised blood pressure, and prevention of health complications [40–44]. The knowledge of a disease condition, has been found to influence attitudes, practices, treatment adherence and lifestyle modification, which in turn impact the management of the condition and the control of the modifiable risk factors of hypertension [45,46]. Several models of health have emphasized the importance of knowledge in fostering positive health behaviors and long-term behavioral change [47–49]. The information-motivation-behavioral skills (IMB) model, proposed by Fisher and Fisher (2000), propounds that the important determinants of initiation and sustenance of positive health behaviors, include comprehensive knowledge related to the health behavior change, personal and social motivation to translate that knowledge into practice, beliefs and attitudes towards the health behavior, social support, self-efficacy and skills to carry out the preventive health behavior successfully [50]. Research evidence has shown the prevalence of poor knowledge about hypertension, especially among hypertensive patients in countries undergoing epidemiological transition [38,51,52]. Adequate knowledge about hypertension was found to motivate patients, to engage in positive lifestyle modifications such as weight reduction, moderation of alcohol consumption, regular physical exercise, and a healthy diet rich in vegetables and fruits [40].

Several studies conducted across the world have found that hypertensive patients, lack knowledge regarding the definition of hypertension, normal BP values, nature of the disease, adverse health complications of letting asymptomatic conditions such as hypertension remain untreated, optimal values of systolic and diastolic measures, classifications of normal and elevated BP levels, the significance of elevated BP levels [53], risk factors such as unhealthy diet, obesity, cigarette smoking, sedentary lifestyle patterns, high alcohol intake, and excessive salt and fat intake, the importance of exercise, causes, adverse health related complications of uncontrolled hypertension [54–60], the importance of medication adherence and positive lifestyle modifications for the management of their condition [61,62], the status of their BP control, the severity of hypertension, impact and consequences of unhealthy dietary habits on their BP levels, the importance of healthy dietary regimes [63] and the asymptomatic nature of their condition [35]. Research evidence has indicated that adequate knowledge about hypertension and lifestyle modifications, was associated with enhanced medication adherence, lifestyle regimen adherence, health behavior change and BP control outcomes whereas poor knowledge about hypertension and lifestyle changes, was associated with health risk behaviors, inadequate medication and lifestyle adherence and sub-optimal BP control outcomes among hypertensive patients [62,64].

The impact of patient health education interventions, on hypertension control outcomes has been assessed through improvements in knowledge, clinical and therapeutic adherence behaviors among hypertensive patients [63]. A comprehensive scientific literature review, indicated a lack of standardized instruments to measure hypertension-related

knowledge, among the Indian hypertensive population. The Hypertension Knowledge Test[65], the Hypertension Knowledge-Level Scale[66], the HIPER-Q[67]and the Hypertension Knowledge Interview Schedule [68],were psychometrically validated among the Korean American, Turkish, Brazilian and Spanish hypertensive patients, respectively.

A scientific literature review found that among the 50 hypertension knowledge instruments reviewed, 38 instruments were not psychometrically validated[34,35,43,61,69–101], 4 instruments reported only the internal consistency reliability[46,102–104],18 instruments measured only specific domains of hypertension knowledge and 5 instruments used small samples [46,69,82,90,104].Hence it was considered pertinent and relevant to develop and validate the Hypertension Knowledge Test, among the Indian hypertensive population (HKT-I) which is a multi-dimensional clinical and research measurement tool, that quantifies the total knowledge about hypertension as well as knowledge in the domains of general knowledge, lifestyle, management, health complications, and risk factors of hypertension.

METHOD

Study Design and Sampling Procedure

A descriptive, cross-sectional comparative study design was employed, to assess the level of knowledge about hypertension among hypertensive patients, from four villages in the Medchal district in India. The Society for Health and Allied Research, India (SHARE-INDIA), developed a global positioning system mapped database called the Rural Effective Affordable Comprehensive Health Care (REACH) database, containing a list of all the residents in the Medchal district by name, gender, and date of birth [111,112].The sampling frame comprised of the hypertensive patients from the 40 villages, of the Medchal district that were mapped on the REACH database of SHARE-INDIA. The necessary permission was obtained from SHARE-INDIA, to recruit the hypertensive patients from the villages, mapped on their database. A two-stage sampling procedure was employed, with the villages constituting the first unit, and the hypertensive patients constituting the second unit, of the sample. Using a random sampling procedure, 4 villages were selected from the 40 villages in the Medchal district and 56 hypertensive patients from each of these villages, were randomly sampled using a table of random numbers for inclusion in the study. The Cochran's formula was used to determine the sample size for the study, given that the population proportion of hypertension in the Medchal district was 20%, with a 95% confidence interval and a 5% margin of error[113].

Setting and Participants

The study sample was recruited from four randomly selected villages, in the Medchal district in Telangana in India, and comprised of 224 hypertensive patients randomly selected, using a table of random numbers. The Hypertension Knowledge Test was administered by the principal investigator in the homes of the hypertensive patients.

Written informed consent was obtained from all the hypertensive patients who were willing to participate in the

study. The inclusion criteria indicated that the participants (1) must be known cases of hypertension diagnosed and initiated on treatment for at least 6 months (2) must be in the age-range of 30 and 75 years (3) must be willing to sign the informed consent form. The exclusion criteria were (1) new cases of hypertension diagnosed less than 6 months back(2) the presence of secondary hypertension and co-morbid conditions (3) the presence of a psychiatric disorders or cognitive problems such as dementia.
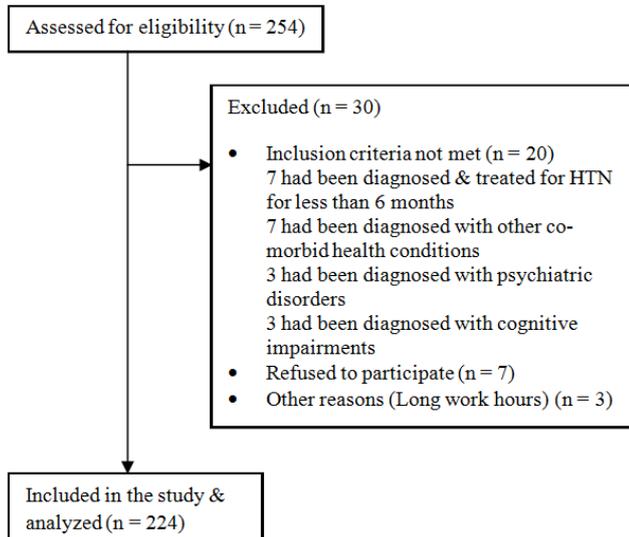

Figure 1 Diagram of patient enrollment

Among the study participants, 61.1% were women and 40% were men. The age of the study participants was found to range between 30and 75 years ($M = 59$, $SD = 10$). Among the study participants, 52.8% were non-literate, 18% had completed their primary school, 11.1% had completed their middle school, 7.4% had passed their tenth grade, 4.2% had completed their under-graduation, 3.2% had completed their intermediate education, 2.3% had completed their post-graduation, 0.9% had completed their high school, and 0.5% were diploma holders. Among the study sample, 56.5% had a family history of hypertension and 43.5% did not have a family history of hypertension.

Instruments and Measurements

The HKT-I was administered along with the Hypertension Therapeutic Adherence Scale (HTAS-I) for Indian hypertensive patients [114] and the Health Beliefs Scale for Hypertensive patients (HBSHP)[115]. Trained and certified community health workers, recorded the blood pressure measurements of the hypertensive patients using standardized procedures, in accordance with the guidelines of the American Heart Association [116].

The Hypertension Therapeutic Adherence Scale for Indian Hypertensive Patients (HTAS-I)

This scale measured the dimensions of medication adherence, dietary adherence, avoidance of harmful health behaviors, appointment keeping, self-monitoring, stress management and regular physical exercise [114]. The scale comprised of 28 items which were measured on a4-point Likert scale ranging from "None of the time" to "All the time". Higher scores on each of the dimensions and on the overall scale, indicated

higher levels of medication and lifestyle regimen adherence, among hypertensive patients. The internal consistency or Cronbach's value of the whole HTAS-I scale was found to be 0.76. The Cronbach's alpha internal consistency values, of the individual sub-scales of medication adherence, dietary adherence, avoidance of harmful health behaviors, appointment keeping, self-monitoring, stress management, and regular physical exercise were found to be 0.82, 0.72, 0.73, 0.69, 0.66, 0.71, and 0.62, respectively. In the current sample, the internal consistency or Cronbach's alpha value for the whole scale, was found to be 0.94 and for the individual sub-scales of medication adherence, dietary adherence, avoidance of harmful health behaviors, appointment keeping, self-monitoring, stress management and regular physical exercise were found to be 0.95, 0.96, 0.88, 0.89, 0.81, and 0.87 respectively.

The Health Beliefs Scale for Hypertensive patients (HBSHP)

This scale comprised of 34 items, and measured beliefs regarding the perceived susceptibility to the adverse health complications of hypertension, perceived severity of high blood pressure, perceived benefits of engaging in positive health behaviors, perceived barriers to medication and lifestyle regimen adherence, and perceived health related self-efficacy among hypertensive patients [115]. The responses were measured on a6-point Likert scale ranging from strongly disagree to strongly agree. The Cronbach's alpha reliability value for the whole HBSHP scale was found to be 0.79. The internal consistency Cronbach's alpha reliability values, of the individual sub-scales of Perceived Susceptibility, Perceived Severity, Perceived Benefits, Perceived Barriers, and Perceived Self-Efficacy were found to be 0.52, 0.54, 0.69, 0.60, and 0.63, respectively. Higher scores on the individual sub-scales, indicated enhanced health beliefs and self-efficacy, in patients' ability to engage in positive behavioral change, for the management of hypertension. In the current sample (N = 224), the internal consistency reliability of the HBSHP, was found to be 0.88 and the Cronbach's alpha reliability values for the perceived susceptibility, perceived severity, perceived benefits, perceived barriers, and perceived self-efficacy sub-scales, were found to be 0.97, 0.89, 0.95, 0.67, and 0.87 respectively.

BP Measurements

The Rossmax (model MJ701f) automated sphygmomanometer was used for BP measurements. Three consecutive BP measurements were obtained, from the right arm of each study participant with the patient seated in a comfortable position, and arm at the level of the heart. There was a gap of 1 minute between consecutive BP readings. An average of the second and third blood pressure readings, constituted the final systolic and diastolic BP measures, for each participant. Trained community health workers used standardized procedures, based on the guidelines of the National Heart Lung and Blood Institute[117], to measure the blood pressure readings of the hypertensive participants.

Procedure: The HKT-I was translated into Telugu and Hindi, then back-translated and cross-checked for accuracy, by the study investigators. Socio-demographic information was obtained prior to the administration of the scales. The time taken for administration of the scales was approximately 20 to

50 minutes. For illiterate patients, the principal investigator read out the items in the scale one after the other, and filled up the scales based on the responses of the participants.

RESULTS

Development and Validation of the HKT-I

The entire process of constructing and validating the test has been described under five phases viz. Phase 1- Item Construction and Content Validation, Phase 2 – Item Analysis, Phase 3 – Exploratory Factor Analysis, Phase 4 – Reliability Testing, Phase 5 – Validity Testing.

Phase 1. Item Construction and Content Validation

Item Construction: The items of the HKT-I scale were developed from the following sources (1) A comprehensive scientific literature review of the existing reliable and valid hypertension knowledge measurement scales (2) Review of the existing literature pertaining to knowledge of hypertensive patients regarding medication and lifestyle regimen adherence, positive health behaviors, prevention, management and control of hypertension (3) The Joint National Committee panel (JNC8) guidelines for the management of hypertension [118] (4) the National Heart, Lung, and Blood Institute hypertension knowledge questionnaire [117] (5) the American Heart Association guidelines for the management of high blood pressure [116] (6) Structured interviews with practicing physicians regarding the important domains of hypertension-related knowledge influencing adherence behaviors among hypertensive patients (7) Structured interviews with hypertensive patients to identify their level of knowledge, misconceptions, and cultural beliefs regarding the treatment of their condition. A total of 80 items related to the causes, risk factors, symptoms, lifestyle modifications, medication adherence, management and control of hypertension were derived from these sources.

The content validity of the 80 items was determined, by submitting this initial item pool to a panel of 10 experts (10 medical doctors) to identify the items which were relevant, to the measurement of hypertension-related knowledge among patients. The panel of experts was asked to rate each item, as relevant or not relevant for the measurement of hypertension-related knowledge, among patients. Based on Lawshe's critical value criterion, 33items which exceeded the criterion of 0.62 (in the case of 10 judges), were included in the final test.

Phase 2. Item Analysis

Item Analysis was carried out in order to identify and retain the best items from the initial pool of items. Two types of item analysis viz. the item difficulty index and the item discrimination index were used to evaluate the characteristics of the items. The item difficulty index was used, to discard those items which were too easy or too difficult to answer, retain those items with an optimal level of difficulty and arrange items on the test in an increasing order of difficulty. The item discrimination index provides an assessment, of how effectively an item discriminates between high and low scorers on the entire test, indicates the extent of association between the response on an item and the overall knowledge

score, and helps determine whether a correct response on an item can be attributed to the level of knowledge regarding hypertension, chance or test bias.

Data analysis was performed using IBM SPSS 20. Two methods of item analysis were used to identify the relevant items – (1) Item-Difficulty Index (p) (2) Item-Discrimination Index (d).

Item-Difficulty Index: The item difficulty index (p) was calculated using the formula by Crocker and Algina [119]: p=Np/N; where Npindicates the number of respondents who answered the item correctly and N denotes the total number of respondents in the group. None of the items were discarded based on the Item-Difficulty index, as all the items were well within the optimal cut-off range, of .10 to .90. The item difficulty values of all the items were calculated and presented in Table 1.

Item-Discrimination Index: The item-discrimination index (d) was calculated for each item by identifying the upper and lower 27% of scorers on the entire test [120]. The item discrimination index for a test item is calculated using the formula: $d = (U - L / N)$; where U = number of respondents in the upper range who answered the item correctly, L = number of respondents in the lower range who answered the item correctly and N = total number of respondents in the upper or lower range. The items with a discrimination value lower than .19,indicated they needed revision as they were "poor" items, and were discarded based on the cut-off range by Ebel and Frisbie [121]. Based on this criterion, items numbers 11 ($d = 0.16$) and 33($d = 0.15$) were discarded. Hence the final version of the test comprised of 31 items as shown in Table1.

Table 1 Item-difficulty value (p), and item-discrimination value (d) of the 33 items

SN	Dimensions & Questions	Item Difficulty Index (*p*)	Item Discrimination Index (*d*)
I	**General Knowledge:**		
	1. Generally the duration of the condition of high BP is	0.83	0.58
	2. High blood pressure	0.81	0.77
	3. High blood pressure	0.72	0.65
	9. All of the following statements are true about high BP except	0.47	0.60
	15. A person is diagnosed with high blood pressure if the BP reading is above	0.78	0.65
	16. The value of the normal BP reading is	0.82	0.56
	26. The symptoms of high BP are	0.51	0.29
	30. Which of the following statements is correct?	0.77	0.27
II	**Lifestyle-related Knowledge:**		
	7. High BP can be effectively managed by	0.75	0.70
	10. The best way to control high BP is	0.75	0.51
	11. The lifestyle changes required to manage high BP are	0.97	0.16
	12. A healthy diet for a high BP patient is	0.77	0.50
	13. Reducing salt intake	0.87	0.43
	14. Which one of the following statements is wrong?	0.79	0.41
	15. Healthy foods for a BP patient are	0.86	0.36

III	Management and Control of Hypertension:		
	17. Medicines for high BP	0.82	0.32
	18. What should a high BP patient do when he/she misses taking their medicine on a day?	0.82	0.27
	19. Which of the following statements is correct?	0.83	0.37
	20. Once a patient's high BP is controlled	0.79	0.28
	21. Which of the following statements is correct?	0.81	0.41
	22. Which of the following statements is correct?	0.77	0.36
	23. If a patient's BP is extremely high	0.86	0.46
	24. Which of the following statements is wrong	0.78	0.35
	25. It is important to inform the doctor that one is taking medicines for high BP during	0.70	0.32
	28. If the high BP medication prescribed by the doctor is not effective in controlling BP levels	0.87	0.36
	29. If a patient feels the symptoms of high BP	0.73	0.45
	31. When BP levels increase	0.75	0.25
	33. High BP can be managed by	0.85	0.15
IV	Hypertension related Health Complications		
	5. The health complications of neglecting high BP are	0.78	0.34
	8. Untreated BP can lead to	0.78	0.45
	27. Which one of the following statements is correct?	0.75	0.28
V	Risk Factors of Hypertension		
	4. Which of the following is not a cause of high BP?	0.43	0.38
	6. Which one of the following statements is wrong?	0.63	0.31

Note: *p* denotes item difficulty index and *d* denotes item discrimination index

Phase 3. Exploratory Factor Analysis (EFA)

The Principal Components Analysis (PCA) method with varimax rotation was used to identify the dimensions constituting theHKT-I among hypertensive patients. The assumptions for executing EFA were met by the data. The Bartlett's Test of Sphericity was significant (p < .000) and the Kaiser-Meyer-Olkin test of sampling adequacy (.84) was achieved. The covariance and communality values for all the items were found to be above .50 and .30 respectively. The factors were selected based on the empirical criterion of Kaiser's eigenvalue being greater than 1 and items with factor loadings above .30 were retained. The results of the EFA were compared with the hypothesized theoretical grouping of items, decided apriori based on a review of the existing scientific literature[114]. The results of the PCA provided empirical evidence for the construct validity of the hypothesized theoretical dimensions of the HKT-I. A five-factor solution emerged which accounted for 75% of the variance in the overall hypertension knowledge. The items within each dimension were examined in order to label the factors. The factors of "Hypertension-related Management and Control", "General Knowledge","Lifestyle-related Knowledge", "Health Complications" and "Risk Factors" explained 20%, 19%, 17%, 10% and 9% of the variance in the total hypertension knowledge scores of the hypertensive participants.

Table 2 Communalities, factor loadings, eigenvalues, percentage of variance explained, number of items, coefficient alpha, and mean inter-item coefficient for the 31-item HKT-I

Original item's no.	Communalities	Factor Loadings				
		1	2	3	4	5
Item 17	.83	.78				
Item 18	.74	.79				
Item 19	.76	.92				
Item 20	.76	.80				
Item 21	.80	.90				
Item 22	.90	.83				
Item 23	.71	.73				
Item 24	.77	.84				
Item 25	.65	.78				
Item 28	.76	.76				
Item 29	.79	.71				
Item 31	.72	.81				
Item 1	.65		.78			
Item 2	.76		.90			
Item 3	.89		.92			
Item 9	.85		.59			
Item 15	.72		.83			
Item 16	.78		.81			
Item 26	.67		.72			
Item 30	.82		.82			
Item 7	.74			.84		
Item 10	.79			.85		
Item 11	.86			.90		
Item 12	.69			.79		
Item 13	.73			.53		
Item 14	.70			.76		
Item 5	.79				.88	
Item 8	.79				.80	
Item 27	.72				.87	
Item 4	.85					.82
Item 6	.60					.84
Reliability Estimates		1	2	3	4	5
Eigenvalue		7.23	6.05	4.15	4.56	4.17
% of variance explained		20%	19%	17%	10%	9%
No. of items		12	8	6	3	2
Coefficient alpha		.94	.89	.92	.84	.71
Mean inter-item correlation		.56	.55	.67	.65	.56

Description of the HKT-I

The final version of the Hypertension Knowledge Test for Indian hypertensive patients (HKT-I), comprised of 31 items structured in the form of questions/statements, with a multiple-choice response format. Each item was given five response options, of which only one response was correct. The 5 hypothesized dimensions constituting the HKT-I were (1) Hypertension related Management and Control (2) General Knowledge (3) Lifestyle-related Knowledge (4) Health Complications (5) Risk Factors. The items from the hypothesized dimensions were arranged in the increasing order of their difficulty in the test. Each correct response was accorded 1 point and the wrong responses and the "do not know" responses were given a score of zero. The maximum score was 31 for the entire test, 12 for "hypertension related management and control",7 for "general awareness", 6 for "lifestyle", 4 for "health complications", and 2 for "risk factors" sub-dimensions of the test. The minimum score was zero for the entire test and for the sub-dimensions.

Phase 4. Reliability Analyses

The Cronbach's alpha internal consistency reliability value of the HKT-I test was found to be .97. The internal consistency reliability values of the "Hypertension-related Management and Control", "General Knowledge", "Lifestyle-related Knowledge", "Health Complications", and "Risk Factors" dimensions were found to be .94, .89, .92, .84 and .71 respectively.

The consistency of the instrument over time was tested by the test-retest reliability method. The HKT-I was initially administered at baseline to 224 hypertensive patients, and was re-administered to the same group of participants 3 weeks after the initial administration of the test. The Pearson's Product Moment Correlation Coefficient was computed, to determine the correlation between the scores on the HKT-I at baseline and re-administration, in order to determine the test-retest reliability of the test. A significant positive correlation was found between the test and retest scores of the hypertensive participants on the HKT-I ($r = .77$, $p < 0.001$). Similarly, statistically significant positive correlations were found between the test retest scores, of the individual sub-scales of hypertension-related management and control ($r = .77$, $p < 0.001$), general knowledge ($r = .70$, $p < 0.001$), lifestyle-related knowledge ($r = .68$, $p < 0.001$), health complications ($r = .72$, $p < 0.001$) and risk factors ($r = .70$, $p < 0.001$). These values established the reliability of the HKT-I.

Phase 5. Validity Testing

Establishment of Convergent and Discriminant Validity

The presence of convergent validity of the HKT-I was demonstrated as all the items had loaded above 0.30 on their respective factors. The discriminant validity of the test was established, by calculating the factor scores using the factor-based scale approach, following which correlations were computed between the factors (Table 3). It was found that none of the factors, had high correlations (>0.70) with the other factors (r ranged between 0.01 to 0.26), thus providing evidence for the discriminant validity of the test.

Table 3 Correlations between factors by taking factor-based scale scores

	1	2	3	4	5
Hypertension related Management	1	.21**	.01	.14	.12
General Awareness		1	.26**	.05	.25
Lifestyle			1	.03	.24**
Health Complications				1	.22
Risk Factors					1
M	.80	.70	.80	.77	.41
(SD)	(0.31)	(0.32)	(0.33)	(0.36)	(0.42)

*Note. *p <.05, **p <.001*

The One-Way Repeated Measures Analysis of Variance (ANOVA) was used to examine the differences across the five factors of the HKT-I. The results of the one-way repeated measures ANOVA, indicated a significant difference across the 5 factor-based scale scores, Wilks' Lambda = 0.12, $F_{(4, 220)} = 376$, $p < .001$, $\eta^2 = 0.878$. Post-hoc pairwise comparisons showed that the five factor-based scales were significantly different from each other, $p < .001$. Post-hoc comparisons (Bonferroni) revealed that Factor 1 or

"Hypertension-related Management and Control" (M = 9.64, SD = 3.78) differed significantly (p < .001) from Factor 2 or "General Knowledge" (M = 4.38, SD = 1.98), Factor 3 or "Lifestyle" (M = 4.85, SD = 1.99), Factor 4 or "Health Complications" (M = 2.32, SD = 1.09), and Factor 5 or "Risk Factors" (M = 0.84, SD = 0.85). Factors 2, 3, 4, and 5 differed significantly (p < .001) from all the remaining factors. Hence, further evidence was provided for the discriminant validity of the HKT-I.

Establishment of Criterion-Related Validity

The criterion-related validity of the HKT-I was established wherein significant relationships were found between the HKT-I scores and the scores of scales measuring related constructs. A scientific literature review indicated a lack of standardized tests measuring the knowledge about hypertension among Indian hypertensive patients. As an alternative, we identified the constructs of hypertension-related therapeutic adherence and hypertension-related health beliefs, which tend to have significant positive relationships with the construct of hypertension-related knowledge [14,40,62]. Scientific literature has shown the construct of blood pressure control, in the form of blood pressure readings to have a negative relationship, with the construct of hypertension knowledge as measured by the newly developed HKT-I [65,122,123]. Hence the concurrent validity of the HKT-I was established, by administering it along with the Hypertension Therapeutic Adherence Scale for Indian Hypertensive Patients [114] and the Health Beliefs Scale for Hypertensive Patients [115]. Standardized blood pressure measurements were also taken to provide evidence for the criterion-related validity of the HKT-I.

The overall hypertension knowledge score and the five dimensions of the HKT-I, shared a significant positive relationship with the overall hypertension therapeutic adherence score, and the seven sub-scales of the HTAS-I (Table 4). Since a majority of the HKT-I dimensions shared significant positive relationships, with the adherence scores of the dimensions of the HTAS-I, the presence of criterion validity was inferred.

The total hypertension knowledge score and the five dimensions of the HKT-I, shared a significant positive relationship with the total health beliefs score, obtained from the HBSHP and the various dimensions of the HBSHP (Table5). It was found that the total hypertension knowledge score and the five factor-based scale scores of the HKT-I, were significantly positively correlated with the perceived susceptibility, perceived severity, perceived benefits and the perceived self-efficacy dimensions of the HBSHP, and were significantly negatively correlated with the perceived barriers dimension of the Health Beliefs Scale.

The scores on the HKT-I were correlated with the systolic and diastolic blood pressure measurements of the hypertensive participants. There was a statistically significant negative relationship, between the hypertension knowledge scores and the systolic ($r = -0.44$, $p = .001$) and diastolic ($r=-0.56$, $p=.001$),blood pressure readings among the hypertensive patients. This finding is consistent with empirical evidence which indicates that, higher levels of knowledge regarding

hypertension among patients is associated with lower blood pressure measurements and enhanced blood pressure control, thus providing further evidence for the criterion-related validity of HKT-I. Based on the JNC-8 criteria for the diagnosis of hypertension, hypertensive patients with a blood pressure reading of 140/90 mm/Hg or higher were grouped under the category 'Uncontrolled Hypertension', and those with a BP reading of less than 140/90 mm/Hg were grouped under the category 'Controlled Hypertension'[118]. The independent samples t test was used to compare the hypertension knowledge scores among those with controlled and uncontrolled hypertension. As hypothesized, hypertensive patients with controlled hypertension ($M = 27$, $SD = 5$), had significantly higher hypertension knowledge scores, as compared to the patients with uncontrolled hypertension ($M = 20$, $SD = 11$); t (222)= 5.91, $p < 0.01$. Hence the criterion-related validity of the HKT-I was established.

DISCUSSION

The purpose of the study was to develop and validate a clinical and research measurement tool, for the assessment of knowledge about hypertension to identify and screen hypertensive patients, in need of health education and to enable health care providers to design health promotion interventions to address these gaps in knowledge.

Scientific evidence has indicated that poor knowledge about hypertension, was found to constitute an important barrier for the effective prevention, treatment, and control of the condition among hypertensive patients[124,125]. Non-adherence to the anti-hypertensive medication has been found to be a major impediment to the management of hypertension[8],resulting in poor prognoses, increased days of hospitalization, higher death rates[126], poor health outcomes, a compromised quality of life and increased health care costs[127].In most communities, only about half of the hypertensive patients are aware of their hypertensive status, about half of those aware are being treated for their condition and only about half of hypertensive patients receiving treatment have their hypertension under control, a situation that has been labeled the "Rule of Halves"[128].

The psychometric analyses of the HKT-I demonstrated good reliability and validity. The principal components analysis method identified five factors, constituting knowledge in the domains of management and control, general knowledge, lifestyle related knowledge, health complications and risk factors of hypertension. The scores on the HKT-I would be useful, to explain and predict hypertension-related knowledge, treatment adherence, hypertension control, and the motivation to engage in positive health behaviors, among hypertensive patients. Low scores on the dimensions of the hypertension knowledge test, would indicate the need for health care providers to recommend hypertensive patients, for patient health education programs and counseling to enhance their medication and lifestyle regimen adherence, thus improving their health outcomes.

The items in the "Management and Control" dimension, were related to the knowledge regarding the importance of regular medication adherence, and the measures to be taken to control raised blood pressure. Improved blood pressure control has been found to be associated with reduced risk of developing stroke, heart failure, myocardial infarction, acute coronary syndrome, and death[129], reduced disability from health complications such as cardiovascular diseases and renal failure, reduced heath care costs and improved quality of life [31].The facilitators to good treatment compliance and improved BP control, among hypertensive patients were found to be good doctor patient communication, awareness of the disease and its adverse health complications, affordability of medications[130], fear of the adverse health complications of hypertension, motivation to achieve optimal BP control, regular clinic visits, not using traditional/complementary medicines, having a strong social support system[131], belief in the efficacy of treatment, availability of drugs, an effective relationship with health care providers [64], improved knowledge and patient health education [62]. Patient health education programs that aim to dismantle the cultural misconceptions, relating to symptoms and medication use have been found to foster, lifestyle modifications and treatment adherence among hypertensive patients[132–134]. Poor knowledge about hypertension and maladaptive health beliefs, rooted in the long-standing cultures of communities were found to be responsible for decisions by patients, to stop the conventional treatment and use traditional or alternative remedies for the management of hypertension resulting in poor health outcomes, inadequate treatment adherence and poor blood pressure control outcomes[40,135].

The items in the "General Knowledge" dimension, were related to the general knowledge regarding hypertension such as the duration, symptoms, cure, and control of the condition as well as the values of normal and elevated blood pressure readings. Several studies conducted across the world have found that the commonly held misconceptions among hypertensive patients, were that it was not necessary to take anti-hypertensive medication on a lifelong basis, medication for hypertension should be taken only in the presence of symptoms, anti-hypertensive medication can be discontinued once BP values are normal [62], hypertension was a temporary and intermittent condition [3,33], the need for medication was intermittent [125], medication can be discontinued when stress disappears [136], medications were not effective in treating hypertension [137], raised BP was only a state of mind, changing one's state of mind would remove the diagnosis, hypertension was caused by over-thinking and not getting enough rest, high BP could result in mental health problems, hypertension was a curable disease, the absence of symptoms meant the absence of the disease[138], the symptoms of high BP such as the blood flowing with greater speed prompt the patient to take the medication[54], western medicine leads to health problems[139], achieving BP control meant a permanent cure, using alternative medicine such as homeopathic and herbal medicines would result in better BP control and cure, spiritual interventions were effective in the treatment of hypertension, hypertension cure can be achieved through homeopaths, native doctors, faith healers and prayers,there was no reason to fear the consequences of medication non-adherence[56], hypertension was announced by the presence of signs and symptoms, high BP was nota serious health condition, poor likelihood of the development of hypertension, and being able to manage the disease without the aid of a physician [98]. A descriptive cross-sectional

qualitative survey conducted among 108 hypertensive patients in Nigeria, found that hypertensive patients possessed several misconceptions regarding their condition, such as patients being characterized by excessive worry, psychological stress, chronic anxiety, fear, nervousness, over-thinking and palpitations [56].

A significant proportion of hypertensive patients, were found to possess poor knowledge, negative perceptions and misconceptions regarding their condition, which were found to act as barriers to positive lifestyle changes and treatment compliance[61].

The "Lifestyle" dimension comprised of items, that tapped the knowledge regarding the lifestyle modifications, to be made for the effective management of hypertension. The management of hypertension requires behavioral change, comprising of a healthy diet intake, moderation of alcohol use, stopping tobacco use, reduction of salt intake, and regular physical exercise[2]. Adherence to the medication and lifestyle regimen, such as the reduction of salt intake, regular physical exercise, moderation of alcohol consumption, and weight reduction were found to significantly decrease blood pressure levels, the risk of cardiovascular mortality[140], coronary heart disease, stroke, chronic kidney disease and all-cause mortality among hypertensive patients [5]. A community based health education program comprising of volunteers, disseminating information on the importance of regular medication adherence, self-monitoring and lifestyle changes such as salt reduction, healthy diet, weight reduction, stress management, alcohol and smoking abstinence, was found to significantly improve the awareness, treatment and control of hypertension in a rural community in Kerala[141]. Cultural misconceptions that drive norms and local practices in a community, such as the use of salt for food preservation, negative stereotypes attached to decreased body weight and exercise, and wrongly perceived benefits of using local stimulants such as tobacco and snuff, were found to act as barriers to positive health behaviors among hypertensive patients[142].

The items in the "Health Complications" dimension, were related to knowledge regarding the adverse health complications, of untreated and uncontrolled hypertension. Hypertension has been found to account for 50% of cardiovascular diseases and 75% of strokes[15], and poorly controlled systolic and diastolic blood pressures have been found to be responsible, for increased cerebrovascular events, cardiovascular events, and all-cause mortality[143]. Untreated and uncontrolled hypertension has been found to lead to irreversible organ damage, disability and death[62].

The items in the "Risk Factors" dimension, were related to knowledge regarding the causes, modifiable and non-modifiable risk factors of hypertension. Scientific evidence has shown that the erroneous causes of hypertension, identified by patients were psychological stress experienced due to daily life difficulties, febrile illness, evil curse, insomnia, the loss of a loved one, marital discord, arthritis and road traffic accidents[56]. The HKT-I comprising of 31 items demonstrated good internal consistency reliability with a Cronbach's alpha value of .97. The individual sub-scales demonstrated satisfactory internal consistency reliability. The criterion-related validity of the HKT-I was established, through significant positive relationships with the dimensions of the Hypertension Therapeutic Adherence Scale (HTAS-I), and the Health Beliefs scale (HBSHP) scores, and significant negative relationships with the systolic and diastolic blood pressure readings. The Exploratory Factor Analysis and correlations between the factor-based scale scores established the convergent and discriminant validity of the HKT-I.

Empowering patients with accurate knowledge, regarding the importance of treatment compliance and dismantling misconceptions rooted in cultural beliefs, have been found to improve adherence behaviors among hypertensive patients[144].

Empirical literature has shown that patient health education programs, have been found to be successful in fostering improvements in knowledge, attitudes, and practices[94], and have been found to be an important determinant of effective disease self-management behaviors, treatment compliance, lifestyle changes, management and control of hypertension, positive health behavior change, control of risk factors such as lack of physical exercise, smoking, and discontinuation of the medical treatment, leading to reductions in the risk of cardiovascular complications, co-morbidities, medical costs, health costs, and mortality among hypertensive patients[145–149].

Targeted patient health education strategies that improve knowledge, regarding medication and lifestyle adherence among hypertensive patients have been successful, in facilitating reductions in stroke incidence by 31% to 45%, myocardial infarction by 20% to 25% and heart failure by more than 50% [38,39,150]. Hence the HKT-I would be a useful screening and measurement tool, to identify hypertensive patients with inadequate knowledge regarding their condition, and establish the impact of patient health education interventions on the management and control of hypertension.

The study has been found to have some limitations. Firstly, a higher proportion of women gave their informed consent for participation in the study, and hence were recruited for the study. As the gender balance was unequal, it may have influenced the study outcomes. Research evidence has indicated that women are more concerned about their health, actively engage in coping efforts and positive health behavior change, and are also more likely to seek therapy and help from health professionals as compared to men[93,151]. Hence future studies must be oriented towards ensuring gender balance to enhance the generalizability of the research findings. Secondly, the instruments used in this study were self-report measures which are a potential source of response bias. However, the use of validated measurement tools would have minimized this bias. Thirdly, the study was limited to hypertensive patients, from four villages in the Medchal district of Telangana in India, and hence the generalizability of the results may be limited. Future studies should be undertaken in diverse communities and geographical areas to enhance the generalizability of the research findings.

CONCLUSIONS AND IMPLICATIONS

In conclusion, the HKT-I was found to be a reliable and valid tool, for the measurement of hypertension-related knowledge among hypertensive patients. The scores on the HKT-I will enable health care providers, to identify patients with low levels of knowledge about their condition, and design health promotion interventions that address these gaps in knowledge, thereby enhancing treatment and lifestyle regimen compliance among hypertensive patients. Low scores on the HKT-I will alert doctors, to recommend hypertensive patients for health education programs and lifestyle counseling, thereby facilitating the improved management and control of their condition.

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