Patient Preference and Adherence

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ORIGINAL RESEARCH

Clinical Implementation of the Hill-Bone Compliance to High Blood Pressure Therapy Scale: Antihypertensive Adherence Assessment in a Romanian Cardiology Outpatient Center

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Purpose: To evaluate antihypertensive therapy adherence and to validate the Hill-Bone Compliance to High Blood Pressure Therapy Scale (HBCTS) for implementation in Romanian cardiology outpatient practice.

Patients and Methods: In this cross-sectional pilot study, 144 adult hypertensive patients completed a Romanian-translated, culturally adapted HBCTS. Mean arterial pressure (MAP) served as an indicator of blood pressure control. Receiver operating characteristic (ROC) analysis determined the optimal adherence cut-off, and multivariable modelling assessed the relationship between HBCTS scores and MAP, adjusting for potential confounders. This study was conducted at an outpatient cardiology clinic in Targu Mureş, Romania, Patients inclusion criteria: adult patients (≥18 years) with diagnosed primary hypertension receiving at least one year of continuous antihypertensive therapy, and exclusion criteria: cognitive/communication barriers and secondary hypertension.

Results: The HBCTS demonstrated acceptable internal consistency (McDonald's $\omega = 0.75$; Cronbach's $\alpha = 0.70$) and retained a three-factor structure. ROC analysis identified 50 points as the optimal adherence threshold (AUC = 0.81; sensitivity = 0.83; specificity = 0.57). After adjustment, 52.1% of participants met the adherence criterion. Each one-point increase in HBCTS score corresponded to a 35% increase in the odds of achieving controlled blood pressure (OR = 1.35; 95% CI: 1.19–1.53; $p < 0.001$). Older age was associated with lower probability of adherence (OR = 0.94; 95% CI: 0.89–0.98, $p = 0.006$), whereas permanent employment status increased the chance of higher adherence (OR = 3.36; 95% CI: 1.57–7.22, $p = 0.002$). Patients overreported their adherence by 18.5% compared with MAP-defined blood pressure control.

Conclusion: These findings support the applicability of the HBCTS in Romanian cardiology outpatient settings and identify key demographic factors associated with patient's adherence. The validated scale offers cardiology practitioners a reliable instrument to detect adherence barriers among high-risk patients, thereby supporting the implementation of targeted, patient-centered interventions.

Keywords: hypertension, medication adherence, hill-bone compliance to high blood pressure therapy scale, mean arterial pressure, outpatient cardiology center

Introduction

Hypertension is one of the most prevalent chronic conditions worldwide, and sustained adherence to antihypertensive therapy is essential for achieving effective blood pressure (BP) control and reduction of cardiovascular risk. [1,2] In Romania, this challenge is particularly pronounced, as the SEPHAR studies have reported a hypertension prevalence exceeding 40% of the adult population, alongside persistently suboptimal control rates despite improved awareness and treatment uptake.[3]

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In cardiology outpatient settings, patients often contend with more complex treatment regimens, greater disease severity, and elevated cardiovascular risk profiles than those seen in primary care—factors that may influence consistent medication-taking behaviors.[4–7]

Clinical practice guidelines underscore the importance of constant treatment, as non-adherence is directly linked to poorer outcomes and increased cardiovascular events.[8,9] Although adherence rates to antihypertensive therapy in Europe are generally reported between 60% and 70%, accurately assessing patient behaviour in routine cardiology practice remains challenging.[10] Available methods—pill counts, pharmacy refill data, electronic monitoring, and biochemical assays—each have strengths and limitations in terms of cost, feasibility, and patient burden.[11–13] In addition, cardiology specialists may influence adherence differently than primary care providers, through more frequent follow-up, individualized dose adjustments, and the management of treatment-resistant cases.[14,15] Evidence suggests specialized cardiology settings may improve adherence assessment accuracy through structured follow-up and frequent monitoring, though actual adherence rates may vary depending on medication complexity and disease burden.

Self-report questionnaires provide a practical and cost-effective method for routinely identifying obstacles to medication adherence.[16]

Although these tools may overestimate actual adherence compared with electronic monitoring or biochemical assays, they offer valuable insights into patient-centered behavioral factors—including medication-taking patterns, appointment adherence, and lifestyle modifications—that influence treatment success.[17–19]

The Hill-Bone Compliance to High Blood Pressure Therapy Scale (HBCTS) is a well-established, multidimensional instrument specifically designed to assess adherence to antihypertensive therapy.[13–15,20–22] Its internal consistency and criterion performance, however, have not yet been evaluated in Romanian specialized cardiology non-inpatient facility.[20,23] Originally developed for urban American patients with hypertension, the HBCTS has demonstrated variable performance across populations and clinical settings, underscoring the need for context-specific validation.

This exploratory study—the first of its kind in Mureș County, Romania—investigates antihypertensive therapy adherence in a specialized cardiology outpatient clinic using the HBCTS.[21]

The primary hypothesis assumed an inverse association between HBCTS scores and mean arterial pressure (MAP) values— whereby higher adherence scores would correspond to lower MAP values, indicative of improved blood pressure control, after adjustment for relevant confounders.

By validating the HBCTS in a cardiology setting and establishing normative values for Romanian patients, our study addresses a major disparity in local hypertension management. The resulting tool allows cardiologists to detect patient-specific adherence challenges and to deliver targeted, high-yield interventions in routine care.

Materials and Methods

Study Design

A cross-sectional observational study was performed in a dedicated outpatient cardiology clinic to examine the association between medication adherence—assessed via the HBCTS—and BP control, quantified by mean arterial pressure (MAP). The outpatient cardiology practice was chosen to evaluate the scale's utility in a specialized setting, where accurate adherence assessment is essential for managing high-risk patients receiving complex treatment regimens.[8] Comprehension-check items were after the questionnaire to assess participant understanding of the instrument. Data collection was carried out from October 2021 to February 2024.

Prior to data collection, the HBCTS was translated and culturally adapted to follow the standardized seven-step protocol recommended for cross-cultural instrument validation.[24] Before applying the Romanian version of HBCTS for the study group (144 patients) a preliminary translated version was administered to a pilot group of 50 patients.[25] The Romanian version of the HBCTS maintains the original three-domain structure: medication-taking behavior (9 items), appointment-keeping (2 items), and sodium intake reduction (3 items).

Sample Size Justification for Questionnaire Validation

An adequate sample size was essential for robust statistical validation.[26] Standard guidelines for exploratory factor analysis (EFA) recommend a subject-to-item ratio of 5:1 to 10:1, indicating that 70–140 participants are appropriate for a 14-item instrument.[27] The inclusion of 144 participants thus satisfies these criteria and adheres to best practices in psychometric validation research.[28]

A review of validation studies revealed subject-to-item ratios ranging from 1.2:1 to 28:1 (median ≈ 6:1).[29,30] While larger sample sizes could enhance stability and generalizability of factor solutions, smaller samples may still yield valid results when item communalities are high, and factor structures are well-defined.[24]

Patient Recruitment and Setting

The outpatient cardiology clinic was chosen for its comprehensive patient database, high volume of individuals with hypertension, established research infrastructure, and institutional affiliation with the George Emil Palade University of Medicine, Pharmacy, Science, and Technology of Târgu Mureș. A convenience sample of 144 adults (≥ 18 years) with diagnosed hypertension (HTN) and at least one year of continuous antihypertensive therapy was recruited consecutively at the conclusion of routine follow-up visits. The pilot cohort (n=50) for translation validation was recruited separately and excluded from the main analysis (n=144), though both samples originated from the same clinic population. Exclusion criteria comprised any medically documented cognitive or communication barrier that could compromise questionnaire completion, as well as secondary hypertension, thereby preserving the study's focus on primary hypertension management.

Blood Pressure Measurement and Data Collection

Hypertension was defined according to the European Society of Hypertension/European Society of Cardiology guidelines in effect at the time of the study.[31] BP was measured using a validated oscillometric monitor (Omron M3 Comfort™, HEM-7155-E; Omron Corporation, Kyoto, Japan). Measurements were obtained at the conclusion of routine follow-up visits after 5 minutes of seated rest. Three consecutive readings were taken at 1-minute intervals, with the mean of the second and third readings used for analysis, following European Society of Hypertension guidelines. Mean arterial pressure (MAP), a more physiologically stable indicator of blood pressure control than separate systolic or diastolic values, was derived from the equation: MAP = DBP + (SBP−DBP)/3 where SBP and DBP denote systolic and diastolic blood pressure, respectively.[32,33] Uncontrolled or treatment-resistant hypertension was classified by a MAP ≥ 100 mmHg, reflecting thresholds established in prior research and clinical practice for elevated cardiovascular risk.[34]

Demographic variables recorded comprised age, gender, place of residence, educational attainment (ISCED-6 classification), and employment status.[35] These covariates were incorporated into multivariable analyses as potential confounders, given their established associations with both medication adherence behaviors and clinical outcomes in hypertensive cohorts.[36–43]

Standardized verification procedures were implemented during data collection to minimize item nonresponse. The dataset underwent a completeness audit prior to analysis, confirming that all key variables were available for statistical evaluation.

Statistical Analysis

All analyses were performed in R version 4.2.3 (R Foundation for Statistical Computing) within the RStudio IDE (RStudio, PBC, Boston, MA, USA, https://posit.co/products/open-source/rstudio/).

Descriptive statistics summarized demographic, clinical, and behavioral characteristics. Continuous variables were presented as means ± standard deviation (SD), whereas variables with non-parametric distributions are expressed as median (interquartile range [IQR] 25–75).

Categorical variables were expressed as frequencies and percentages. Group differences were analyzed using Chi-square or Fisher's exact tests for categorical variables and independent *t*-test or Mann–Whitney *U*-test for continuous variables, depending on normality assessment.

Scale reliability was assessed using McDonald's omega (ω), and Cronbach's alpha (α).[44,45] To facilitate comparison with existing literature and adhere to conventional reporting standards, scale reliability was assessed using Cronbach's α values are also reported alongside McDonald's ω coefficients.[23,46,47]

To evaluate the association between adherence (HBCTS scores) and BP control (MAP), both bivariate and multivariable approaches were applied. Spearman rank correlation coefficient quantified the unadjusted relationship between total HBCTS scores and MAP. Domain-specific correlations were likewise examined by calculating Pearson's r for each HBCTS subscale (medication-taking, appointment-keeping, and salt restriction) against MAP.

Predictor multicollinearity was evaluated via variance inflation factors (VIF), with VIF ≥ 5 denoting significant collinearity.[48] Variables exceeding this threshold were either excluded or combined with conceptually related measures to prevent inflation of coefficient variance. To control for confounding and stabilize coefficient estimates, ridge-penalized regression was applied: linear ridge regression for MAP as a continuous outcome and logistic ridge regression for dichotomous blood pressure control status (controlled: MAP < 100 mmHg; uncontrolled: MAP ≥ 100 mmHg).[49] Logistic regression (ridge penalization) was employed to address multicollinearity and yield stable coefficient estimates when predictor intercorrelations exceeded acceptable thresholds. The optimal ridge penalty (λ) was determined by 10-fold cross-validation. Sensitivity analyses compared ridge-penalized coefficient estimates and odds ratios with those from unpenalized models to assess the impact of regularization and confounder adjustment.

The optimal diagnostic threshold was selected using the Youden Index on the receiver operating characteristic (ROC) curve. Model discrimination was evaluated using the area under the ROC curve (AUC).[50] Statistical significance was defined as a p-value ≤ 0.05. All confidence intervals (CI) were computed at 95%.

Our revalidation protocol adheres to Bland and Altman's recommendation that clinical questionnaires attain a Cronbach's α of at least 0.90—a level crucial for specialist decision-making that previous Romanian versions have failed to reach.[18,23,51] Adopting this more stringent reliability threshold underscores the necessity of precise adherence assessment in high-risk cardiology cohorts, where treatment choices have profound consequences for cardiovascular outcomes.[52,53]

Results

Translation and Cultural Adaptation of the HBCTS Romanian Version

Demographic characteristics and comprehension-check results for the initial cohort of 50 patients are summarized in Tables 1 and 2.

Under the principal investigator's supervision, the culturally adapted Romanian HBCTS was administered to 144 patients, whose socio-demographic characteristics are presented in Table 3.

Table 4 summarizes the distribution of HBCTS responses.

Reliability and Internal Consistency

The scale's reliability, as evaluated by McDonald's omega (ω), was 0.75. The internal consistency of the questionnaire was also assessed using Cronbach's alpha, yielding a coefficient of 0.70, indicative of acceptable reliability. Item-total correlation analysis and Cronbach's alpha recalculation following stepwise item exclusion confirmed the internal consistency of the instrument.

Validity Assessment and Factor Analysis

The HBCTS Romanian version was examined via Spearman's rank correlation coefficient assessing the sign and magnitude of the relation between individual questionnaire items and total adherence scores. Additionally, Exploratory Factor Analysis (EFA) was performed to identify latent constructs underlying the questionnaire's structure within the Romanian healthcare context, thereby substantiating its content validity (see Table 5).

These results underline both the construct and content validity of the Romanian HBCTS in hypertensive patients followed up in an outpatient cardiology setting.

Table 1 Demographic Data of Selected Patients for Pilot Testing of HBCTS Romanian Version

Parameter	Entire Cohort (n = 50)
Age (years, mean ± SD)	65.5 ± 12.2
Gender (female, n, %)	26 (52.0)
Place of residence (urban, n, %)	26 (52.0)
Hypertension (years, mean ± SD)	
Diagnosis	10.76 ± 7.67
Treatment	9.18 ± 6.53
HBCST completion time/minutes (mean, 95% CI)	7.7 (3–20)
Education level (n, %)	
ISCED 0-4	5 (10)
ISCED 5-6	38 (76)
ISCED 7-8	7 (14)
Employment status (n, %)	
Permanent	7 (14)
Unemployed	1 (2)
Retired	38 (76)
Other / Not specified	4 (8)

Abbreviations: HBCST, Hill-Bone Compliance to High Blood Pressure Therapy Scale; ISCED, International Standard Classification of Education; n, number of patients; SD, standard deviation.

Table 2 Comprehension Verification Items

How did you feel about the time spent answering the questions in the questionnaire? (n, %)	**Too long**	**Acceptable**	**Short, did not bother me**
	1 (2)	24 (48)	25 (50)
If you only think about the shoulder questions in the questionnaire, are they? (n, %)	**Too few**	**Sufficient**	**Too many**
	5 (10)	41 (82)	4 (8)
		NO	**YES**
Did you find the quiz difficult? (n, %)		47 (94)	3 (6)
Have you come across questions you do not understand? (n, %)		48 (96)	2 (4)
Have you come across questions that are difficult to answer? (n, %)		48 (96)	2 (4)
Have you come across words in your questions that you do not understand? (n, %)		48 (96)	2 (4)

Abbreviation: n, number of patients.

Table 3 Baseline Socio-Demographic Profile of the Study Cohort

Parameter	Entire Cohort (n = 144)
Age (years, mean ± SD)	65 ± 11.03
Gender (male, n, %)	73 (50.69)
Place of residence (urban, n, %)	78 (54.17)
Hypertension (years, mean ± SD)	
Diagnosis	11.60 ± 8.96
Treatment	9.99 ± 8.01

(*Continued*)

Table 3 (Continued).

Parameter	Entire Cohort (n = 144)
Educational level (n, %)	
ISCED 0–3	20 (13.89)
ISCED 4–6	84 (58.33)
ISCED 7	6 (4.17)
ISCED 8	34 (23.61)
Employment status (n, %)	
Permanent	28 (19.44)
Unemployed	8 (5.56)
Retired	104 (72.22)
Other / Not specified	4 (2.78)

Abbreviations: ISCED, International Standard Classification of Education; n, number of patients; SD, standard deviation.

Table 4 Item-Level Response Distribution for the Romanian-Adapted HBCTS

Question	All the Time (%)	Most of the Time (%)	Sometimes (%)	Never (%)
1. How often do you forget to take your high blood pressure medicine?	6.25	3.47	22.92	67.36
2. How often do you decide NOT to take your high blood pressure medicine?	2.08	0.69	15.28	82.99
3. How often do you eat salty food?	6.25	18.75	68.75	6.25
4. How often do you shake salt on your food before you eat it?	4.86	11.81	49.31	34.03
5. How often do you eat fast food?	0.69	3.47	31.25	64.58
6. How often do you make the next appointment before you leave the doctor's office?*	37.50	31.94	13.89	16.67
7. How often do you miss scheduled appointments?	2.78	0.69	11.81	84.72
8. How often do you forget to get prescriptions filled?	3.47	0.00	7.64	88.89
9. How often do you run out of high blood pressure pills?	0.69	0.69	11.11	87.50
10. How often do you skip your high blood pressure medicine before you go to the doctor?	2.78	1.39	11.81	84.03
11. How often do you miss taking your high blood pressure pills when you feel better?	2.78	4.86	13.89	78.47
12. How often do you miss taking your high blood pressure pills when you feel sick?	0.69	0.00	10.42	88.89
13. How often do you take someone else's high blood pressure pills?	0.00	0.00	1.39	98.61
14. How often do you miss taking your high blood pressure pills when you are careless?	1.39	2.08	11.11	85.42

Table 5 Exploratory Factor Analysis: Item Loadings on the Three Adherence Domains of the Romanian-Adapted HBCTS

Question	Medication Taking (r)	Appointment Keeping (r)	Salt Intake (r)
1. How often do you forget to take your high blood pressure medicine?	0.68*	0.21*	0.20*
2. How often do you decide NOT to take your high blood pressure medicine?	0.53*	0.07	0.20*
3. How often do you eat salty food?	0.27*	0.05	0.80*
4. How often do you shake salt on your food before you eat it?	0.20*	−0.04	0.81*
5. How often do you eat fast food?	−0.09	−0.07	0.54*
6. How often do you make the next appointment before you leave the doctor's office?*	0.15	0.90*	−0.03
7. How often do you miss scheduled appointments?	0.13	0.42*	−0.01
8. How often do you forget to get prescriptions filled?	0.44*	0.20*	0.08
9. How often do you run out of high blood pressure pills?	0.50*	0.16	0.16
10. How often do you skip your high blood pressure medicine before you go to the doctor?	0.54*	0.12	0.18*
11. How often do you miss taking your high blood pressure pills when you feel better?	0.53*	0.17*	0.21*
12. How often do you miss taking your high blood pressure pills when you feel sick?	0.35*	0.09	0.01
13. How often do you take someone else's high blood pressure pills?	0.17*	−0.10	−0.03
14. How often do you miss taking your high blood pressure pills when you are careless?	0.46*	0.04	0.12

Notes: Hill-Bone Compliance to High Blood Pressure Therapy Scale; r, Spearman's rank correlation coefficient. The asterisk (*) denotes statistical significance at $p \leq 0.05$.

Adherence Threshold Determination for Blood Pressure Control

The ROC curve assessing the HBCTS score's ability to discriminate between controlled and uncontrolled hypertension yielded an AUC of 0.81 (95% CI, 0.74–0.87; $p < 0.001$). The ROC curve is presented in Figure 1.

An optimal cut-off value of 50 points using HBCTS was determined for BP control, using the Youden index, corresponding to a sensitivity of 83% and specificity of 57%. Patients scoring ≥ 50 on the HBCTS were classified as adherent, whereas those with scores < 50 were deemed non-adherent. Each one-point increase in the HBCTS score was associated with a 35% higher likelihood of achieving controlled blood pressure (OR = 1.35, 95% CI: 1.19–1.53, $p < 0.001$).

Confounder Identification and Adjustment

Identification of Potential Confounders

Multicollinearity assessment using the Variance Inflation Factor (VIF) identified a strong correlation (VIF > 0.7) between BP diagnosis duration and BP therapy duration, necessitating the exclusion of BP therapy duration from further analysis to maintain model stability.

Multivariable logistic regression was then conducted to identify independent predictors of high adherence; the detailed findings are provided in Table 6.

Advancing age was inversely associated with high adherence (HBCTS ≥ 50), with each additional year reducing the adherence by approximately 6% (OR 0.94; 95% CI, 0.89–0.98; $p = 0.006$). In contrast, employment status emerged as a strong positive predictor, tripling the likelihood of high adherence (OR 3.36; 95% CI, 1.57–7.22; $p = 0.002$).

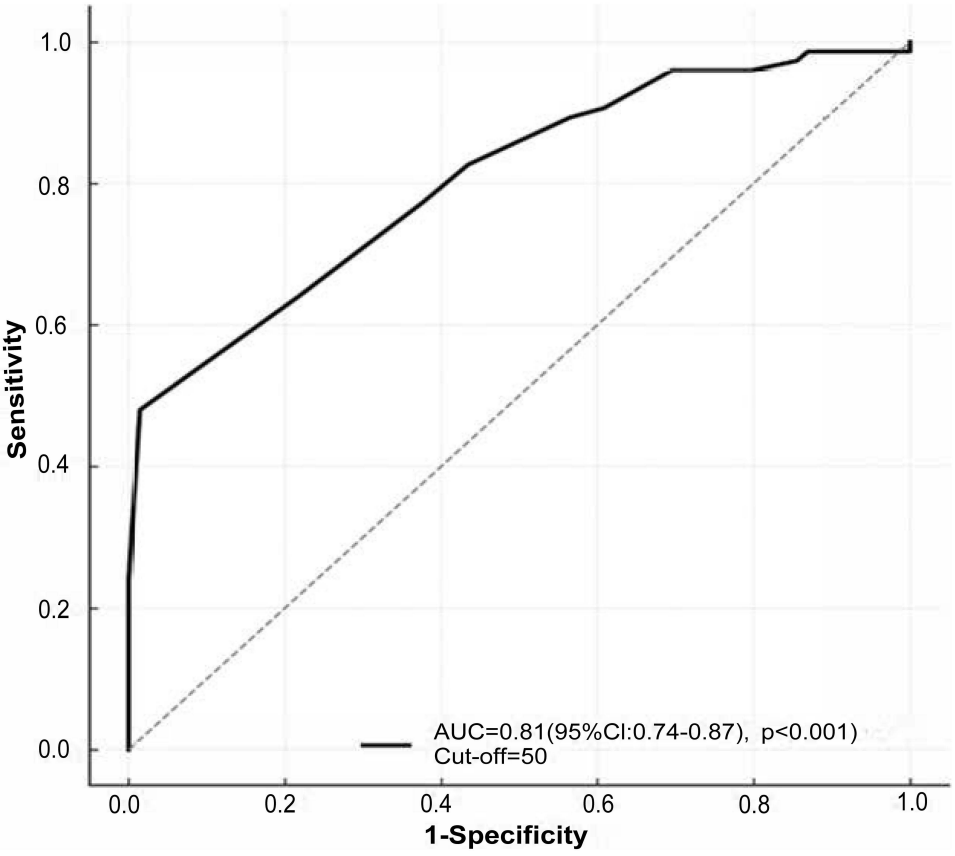

Figure 1 Receiver Operating Characteristic Curve for HBCTS Predicting Controlled Blood Pressure (MAP < 100 mmHg).

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Table 6 Multivariable Logistic Regression of Predictors of High Adherence (HBCTS ≥ 50)

Variable	OR	95% CI	p-value
Intercept	2.7	0.12–60.79	0.531
Age	0.94	0.89–0.98	0.006
Gender (female)	0.76	0.35–1.68	0.499
Educational attainment	1.08	0.91–1.29	0.368
Place of residence (urban)	1.39	0.63–3.05	0.413
Employment status	3.36	1.57–7.22	0.002
Hypertension			
Diagnostic (years)	0.97	0.9–1.05	0.517
Treatment (years)	1.06	0.96–1.16	0.236

Note: Hill-Bone Compliance to High Blood Pressure Therapy Scale.
Abbreviations: CI, confidence interval; OR, odds ratio.

Adjustment for Confounders and True Adherence Estimation

After adjusting for confounders, 52.08% of patients were identified as truly adherent (adherence independent of confounders).

When we compared the proportion of patients with objectively controlled BP to those distinguished as adherent by the HBCTS (score ≥ 50), the overestimated adherence was about 18.47%—lower than that reported in other studies.[7] These findings suggest that while adherence is significantly associated with BP control, external variables contribute substantially, highlighting the necessity of a multidimensional approach to adherence assessment.

Discussion

Summary of Key Findings

This pilot study is the first to apply the Hill-Bone Compliance to High Blood Pressure Therapy Scale (HBCTS) in a cardiology outpatient setting in Mureş County, Romania.

This specialized environment—distinguished from primary care by structured follow-up protocols, frequent specialist encounters, and greater patient engagement—offers a unique context for assessing adherence. After adjustment for relevant confounders, our analysis showed that approximately 52% of patients were truly adherent.

These findings are consistent with European studies reporting adherence rates of 60–70% to antihypertensive therapy, although our adjusted rate of 52.08% indicates a more stringent estimate when accounting for confounders. The observed 18.47% overestimation between self-reported adherence and objective blood pressure control is slightly lower than the 20–30% discrepancies commonly documented in primary care settings, which may reflect the closer monitoring and structured follow-up inherent to specialized cardiology practice. Detailed comparisons with international HBCTS validation studies are provided in Contextualization Within Existing Literature.

Employment status emerged as a significant positive predictor of adherence, whereas advancing age was associated with reduced likelihood of adherence.

Integrating mean arterial pressure (MAP) with HBCTS scores offered a practical strategy for adherence evaluation; however, 24-hour ambulatory blood-pressure monitoring would provide a more comprehensive assessment.[54]

The Romanian-translated and culturally adapted HBCTS exhibited acceptable internal consistency in this population.

Interpretation of Findings

Integrating the HBCTS into an outpatient cardiology setting confirms its utility as a routine instrument for monitoring antihypertensive adherence. The instrument exhibited acceptable internal consistency in this Romanian cohort (McDonald's $\omega = 0.75$; Cronbach's $\alpha = 0.70$), confirming its suitability for research applications. However, although

this α value meets standard requirements for group-level studies, it falls short of the α ≥ 0.90 benchmark proposed by Bland and Altman (1997) for individual-level, high-stakes clinical decision-making.[18]

Exploratory factor analysis (EFA) confirmed the original three-domain structure—medication taking, salt intake, and appointment keeping—mirroring results from other cross-cultural adaptations. This structural congruence reinforces the HBCTS as a robust, multidimensional instrument for assessing antihypertensive adherence across diverse settings.[7,55]

At the 50-point cutoff, the scale achieved a sensitivity of 0.83 and a specificity of 0.57. This calibration prioritizes the accurate identification of truly adherent patients, accepting a moderate rate of false negatives.[56] Such a sensitivity-focused trade-off is clinically appropriate given the imperative to correctly recognize individuals maintaining both high adherence and blood-pressure control.

For patients with borderline HBCTS scores (48–52 points), an individualized clinical assessment that integrates self-reported adherence with objective markers—such as MAP values, prescription refill data, or biochemical assays—is warranted to guide and optimize therapeutic decision-making.

The significant association between HBCTS scores and blood pressure control—with a 35% increase in the odds of achieving control for each one-point increase—underscores the scale's predictive validity in this clinical population.

Moreover, the finding that only about half of the cohort met adherence criteria after accounting for confounders highlights the necessity of a multidimensional assessment strategy—one that integrates both behavioral and physiological measures rather than relying solely on self-report or isolated BP readings.

When self-reported adherence (70.55% with HBCTS ≥ 50 points) was compared with objective blood pressure control (52.08% with MAP < 100 mmHg), an 18.47% overestimation was observed—lower than the 20–30% discrepancies typically reported in primary care studies.[57] The overall overestimation adherence rate likely reflects the enhanced clinical context of our specialized outpatient cardiology setting, where frequent provider engagement and structured follow-up visits may promote more accurate self-reporting.[58]

Effect of Clinical Environment on Outcomes: Comparison with Primary Care Settings

This study was conducted in a specialized outpatient cardiology center, in contrast to primary care settings where patients largely self-manage and interact with providers infrequently. Such reduced supervision can inflate self-reported adherence, as noted in adaptations from primary care populations.[9,59]

By contrast, our cohort received intensive medical oversight—frequent cardiology consultations and structured follow-ups—that likely enhanced the accuracy of adherence reporting. Regular, specialist-led encounters reinforce therapeutic goals and regimen compliance, while the systematic outpatient framework offers multiple opportunities for patients to reflect on and report their medication-taking behaviors.[60,61] Additionally, socioeconomic and access barriers identified in less structured environments may be mitigated by the heightened patient engagement and education inherent to our specialized setting.[62]

Contextualization Within Existing Literature

These findings highlight the need for tailored interventions that address both behavioral and social determinants of adherence—particularly among older adults, rural women, and individuals with lower educational attainment—so as to improve hypertension outcomes in high-risk subgroups.[63]

Against the backdrop of Romania's elevated cardiovascular risk profile, our single-center validation of the HBCTS delivers locally relevant adherence data while enabling direct comparison with international cohorts.[64] The instrument's internal consistency in our sample (Cronbach's α = 0.70; McDonald's ω = 0.75) closely mirrors prior validations in Turkey (α = 0.72), Poland (α = 0.85), and earlier Romanian work (α = 0.73).[20,22,23] By reporting both α and ω, we provide a more nuanced assessment of the scale's psychometric properties, with ω better capturing its multidimensional structure.[64]

Moreover, each one-point increase in HBCTS score was linked to significantly higher odds of achieving target MAP —findings that echo existing literature on adherence–outcome relationships. [65] The 50-point cutoff established via ROC analysis offers a clinically meaningful benchmark tailored to Romanian patients, while the observed 18.5% gap between self-reported adherence and MAP-defined control parallels discrepancies reported elsewhere.[65] Our specialized outpatient

cardiology environment—with its frequent, structured follow-ups and enhanced patient engagement—likely mitigated overestimation biases commonly seen in less supervised settings.

Methodological Considerations

Our blood-pressure measurement protocol—averaging the final two of three consecutive readings—adheres to current best practice and substantially reduces random error versus single-reading methods, thereby strengthening the validity of MAP as an objective adherence metric.

We employed a rigorous, stepwise approach to adapt the HBCTS: initial forward-and-back translation and cognitive debriefing guaranteed linguistic and cultural appropriateness, after which we conducted comprehensive statistical validation to confirm the scale's factorial structure and clinical relevance. Embedding this process within a real-world outpatient cardiology setting then enabled us to evaluate the instrument's performance under authentic clinical conditions.

The modest discrepancy between McDonald's ω (0.75) and Cronbach's α (0.70) ($\Delta = 0.05$) reflects violations of tau-equivalence—items contribute unequally to the total score despite measuring a common construct.[46] This justified selecting ω as the principal reliability coefficient, since it accommodates multidimensional factor loadings more effectively.[66] Future users of the HBCTS should report both α and ω, while giving primacy to ω for a more accurate appraisal of internal consistency.

Strengths and Limitations

Conducting this research within a regional outpatient cardiology practice in Mureș County afforded several methodological strengths. By recruiting a geographically defined cohort from a cardiology-specific referral network, we were able to include patients with diverse cultural and educational backgrounds. The rigorous forward-and-back translation and cultural validation of the HBCTS, combined with our structured MAP measurement protocol (averaging two of three readings) and systematic follow-up visits, enhanced both linguistic appropriateness and measurement precision. Moreover, comprehensive adjustment for key confounders strengthened the internal validity of the association between self-reported adherence and objective blood-pressure control.

However, important limitations must be acknowledged. Reliance on self-reported adherence exposes our findings to recall bias and social-desirability effects, which can inflate true adherence rates.[67] The cross-sectional design provides only a snapshot in time, preventing causal inferences and long-term adherence evaluation. We also excluded patients with medically documented cognitive or communication impairments—despite evidence of lower adherence in these groups—to ensure valid informed consent and questionnaire completion; this necessary step, however, limits the generalizability of our results to more vulnerable subpopulations.[68] Finally, although MAP offers a pragmatic objective metric, emerging data question its sensitivity as a standalone hypertension marker, indicating that future studies should consider ambulatory or 24-hour monitoring for a more comprehensive assessment of adherence outcomes.

Implications and Future Directions

Our findings underscore the importance of systematically identifying adherence gaps in order to design targeted interventions for hypertension management. The Romanian-adapted HBCTS proved to be a pragmatic instrument for clinical practice: applying the 50-point cut-off enables clinicians to promptly detect patients at risk of non-adherence who may benefit from structured counselling and intensified monitoring.

Medication-taking behavior emerged as the most influential predictor of blood pressure control, highlighting the central role of patient education and support. The modest positive association between longer disease duration and adherence further suggests that established treatment routines and sustained clinical engagement can reinforce long-term compliance.

The comparison with primary-care studies also demonstrates how healthcare context shapes adherence measurement: within a cardiology outpatient environment—characterized by regular specialist encounters and standardized follow-ups—self-reported HBCTS scores correspond more closely to objective blood pressure control metrics than in less

structured primary-care settings, where irregular supervision may amplify reporting biases.[69] Recognizing these contextual differences is essential when adapting adherence tools across health systems.[61]

To enhance measurement precision and support personalized adherence strategies—particularly in patients with multiple comorbidities—future research should integrate self-reported tools like the HBCTS with objective adherence metrics such as pharmacy refill records or electronic monitoring. Multicenter, longitudinal studies are also needed to strengthen generalizability, validate predictive accuracy, and inform the development of tailored, patient-centered interventions to improve hypertension outcomes in Romania.

Conclusions

This study provides the first validation of the Hill-Bone Compliance to High Blood Pressure Therapy Scale (HBCTS) in a Romanian cardiology outpatient population. The Romanian-adapted instrument preserved its original three-domain structure and demonstrated acceptable internal consistency, confirming its suitability for research and routine adherence assessment in specialized cardiovascular care.

At the optimal cut-off of 50 points, the HBCTS effectively discriminated between controlled and uncontrolled blood pressure, with each additional point conferring a 35% higher likelihood of achieving target mean arterial pressure. True adherence was achieved by just over half of participants after adjustment for confounders, and self-reported scores overestimated adherence by 18.5% compared with objective blood pressure control. These findings highlight the tool's predictive validity while also underscoring the persistent gap between perceived and actual adherence.

By identifying employment status as a positive predictor and advancing age as a negative predictor of adherence, this study emphasizes the importance of tailoring adherence interventions to patient-specific sociodemographic profiles. The HBCTS questionnaire thus offers clinicians a pragmatic, low-cost instrument to detect barriers in high-risk groups, complementing objective measures and supporting patient-centered management strategies.

Although limited by its single-center, cross-sectional design, this pilot validation establishes locally relevant benchmarks and provides a foundation for multicenter, longitudinal studies to confirm generalizability and guide the integration of validated adherence tools into cardiovascular practice in Romania and Eastern Europe.

Abbreviations

AUC, area under the curve; BP, blood pressures; CI, confidence interval; DBP, diastolic blood pressure; EFA, exploratory factor analysis; HBCTS, Hill-Bone Compliance to High Blood Pressure Therapy Scale; HTN, hypertension; ISCED, International Standard Classification of Education; MAP, mean arterial pressure; OR, odds ratio; ROC, receiver operating characteristic curve; SBP, systolic blood pressure; VIF, variance inflation factors.

Data Sharing Statement

The datasets generated during this study are available from the corresponding author upon reasonable request and are not publicly accessible due to applicable data protection regulations.

Ethics Approval and Informed Consent

The study adhered to the principles of the Declaration of Helsinki and received approval from the Medical Ethics Committee for the Clinical Trial of the drug within the Targu Mures County Emergency Clinical Hospital (approval no.: AD-2710/February 21, 2020), Research Ethics Committee of UMFST Targu Mures, (approval no.: 820/March 24, 2020). Informed consent was obtained from all subjects involved in the study.

Consent for Publication

All participants provided consent for publication of research findings, without including any names or personally identifying information included.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors have no conflicts of interest to declare.

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