ARTICLE

How do the guideline recommendations work for you? Patients' perceived effectiveness of therapeutic approaches in arterial hypertension

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Blood pressure remains in the hypertensive range in nearly half of those affected by arterial hypertension despite it being an extremely modifiable risk factor, whereby morbidity decreases significantly upon implementation of lifestyle-based therapeutic approaches. There are significant discrepancies between the S3 guideline's recommendations and its implementation. In this cross-sectional study sampling 160 inpatients with arterial hypertension, we assessed patients' perceptions of secondary prevention therapeutic approaches recommended to them within treatment guidelines. Additionally, we used psychometric questionnaires to assess prevention factors. We conducted a latent class analysis to identify patterns in patients' views, and tested for group differences regarding gender, age, education years, body mass index, psychopathology, and blood pressure. Two latent classes could be identified: Class 1 tended to perceive all recommended therapeutic approaches as helpful and reflected individuals with high-normal blood pressure. Class 2 tended to view recommendations regarding weight reduction, and cessation of nicotine and alcohol use, as less effective and included those with mild hypertension. There were no statistically significant class differences regarding the socio-demographic parameters. We further examined the evaluation of therapeutic approaches independent of classes, with social support reported to be the most effective approach. In conclusion, persistently-elevated blood pressure may be linked to poorer perceptions of therapeutic approaches which are then not implemented. Furthermore, patient-centered treatment planning and concepts such as shared decision-making appear to be central in treating this population regarding secondary prevention.

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INTRODUCTION

Arterial hypertension is a common disease in industrial nations. In Germany, about 20 to 30 million adults have elevated blood pressure [1, 2]. In about 15% of patients in Germany, despite therapeutic measures, blood pressure (BP) remains above the limit of 140 mmHg systolic and 90 mmHg diastolic [3]. Arterial hypertension is long known as a risk factor for stroke, myocardial infarction, as well as cardiac and renal failure [4–6]. In addition, it has been identified as the one most important modifiable risk factor for mortality (see the Robert Koch Colloquium [7]). Hypertensive heart diseases become more relevant in high-income countries [8], causing more than 10 million deaths annually [1].

The benefits of antihypertensive treatment in preventing the development of secondary diseases are well known. The current literature highlights that adherence to medication and lifestyle changes can significantly reduce the risk of cardiovascular diseases and all-cause mortality [9–11] within an optimal BP [12]. The main risk factors for hypertension include physical inactivity, obesity, unhealthy diet, stress and increased alcohol consumption; all of which are considered modifiable and preventable [7]. The S3 guideline (S3G) addresses these risk factors and defines them as basic therapeutic approaches (TA). Depending on the extent of the BP increase, they are supplemented by pharmacological treatment [1].

In the context of compliance research, hypertension has already received some attention [13]. Current conceptualizations of adherence emphasize patient participation in treatment planning, and stress that this must occur within the context of a patient-centered and collaborative relationship with the physician [14]. In this concept, beliefs and subjective perceptions of one's personal impact in preventing or modifying illness using TA seem to be of relevance. Empirical data shows a correlation between adherence and patients' beliefs, their knowledge, and experiences, as well as those of related persons, such as family and friends [13]. Since this is considered to be a decisive influencing factor, inquiring

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patients' beliefs prior to providing any advice may allow the patient's perceptions to be noted and understood. corrected or reinforced. In this study, the terms adherence and compliance are consciously distinguished from each other. In previous studies, the focus was on the latter, which is why it is used in the citation. In fact, most of the studies have been focusing on medication adherence [15] and the best method for lowering BP remains controversial [16]. Hypertensive patients tend to adhere more to medication than to recommended lifestyle changes [17]. A meta-analysis indicates that only about 50% of patients with cardiovascular disease adhere correctly to their medication [18]. Huy et al. found that only about one third adhere to lifestyle changes [19]. The importance of lifestyle modifications is illustrated by Mahmood et al. who award medication-like effects to these interventions [20]. However, there is empirical evidence of significant discrepancies between the recommendations of the guidelines and the individual implementation of these because of low adherence [21]. Studies demonstrate the complexity and diversity of low adherence by identifying over a hundred factors as potential predictors [22]. Most factors focus on personal aspects, such as patients' mental health including depression or anxiety [14, 23]. Psychosocial factors such as family support were even more important to manage the disease successfully [14, 19]. Vermeire et al. emphasize that some studies have identified the quality of the doctor-patient relationship as an important influencing factor [13]. However, to our knowledge, no study to date has directly examined patient perceptions of the effectiveness of S3G recommendations associated with the occurrence of arterial hypertension.

In this exploratory study, we assume that latent classes exist among people with arterial hypertension based on the perceived effectiveness of the S3G recommendations and that these classes differ regarding their baseline BP. Furthermore, we assume that there is a systematic differentiation referring to sociodemographic variables, risk factor profile, and psychopathological findings.

MATERIAL AND METHODS

Study design and recruitment

The cross-sectional study was conducted at the University Hospital Ruppin-Brandenburg (ukrb), which is located in northeast Germany, between March 2019 and May 2020. Inclusion criteria were arterial hypertension diagnosed prior to hospital stay, at least 18 years of age, signed informed consent form and completion of the questionnaire battery. We conducted a Latent Class Analysis (LCA) to identify patterns regarding the evaluation of the S3G recommendations among hypertensive patients, as we assumed that latent classes exist concerning the perceived effectiveness of the S3G and that these classes differ regarding their baseline BP. Furthermore, a differentiation referring sociodemographic variables, risk factor profile, and psychopathological findings was assumed. Our evaluation of hypertensive patient perceptions of the S3G was based on self-developed scales. The latent classes were examined regarding risk factors after retrospectively collecting medical parameters from the electronic file and using standardized psychometric questionnaires. In particular, depression and anxiety were focused on as common comorbidities and well-known potential influencers on adherence [14, 23]. Furthermore, we took socio-demographic information into account in our analysis (namely, gender, age, first language, marital status, number of children, and years of education).

Measurements

Patients' perceived effectiveness of S3 guideline recommendations. To measure perceived effectiveness of TA including lifestyle changes set out within the S3G recommendations, we used a four-point Likert scale in which the participants with arterial hypertension could indicate the extent to which they viewed the recommendations to help them recover from their disease so far. Participants could choose between *did not help at all*, *helped a little*, *helped moderately* and *helped a lot*. TA defined within the S3G were as follows: (a) a healthy diet (in the sense of reduced salt intake, increased consumption of vegetables, fresh fruit, fish, nuts, and unsaturated fatty acids, low consumption of red meat and consumption of low-fat dairy products), (b) abstaining from nicotine and alcohol, and (c) reducing body weight; according to the increase of BP they are augmented with (d) drug therapy [1]. Besides the explicit S3G recommendations, we further examined factors that have been reported to be helpful in the context of prevention: (e) family or social support [14, 19], (f) conversations with the doctor [13, 14] and the (g) reduction of negative emotions [14].

Patient health questionnaire-9. The Patient Health Questionnaire (PHQ-9) captures depressive symptoms based on nine questions that correspond to the Diagnostic and Statistical Manual of Mental Disorders IV-criteria for the diagnose of a major depression [24]. The assessment refers to depressive symptoms (e.g. loss of interest, sleep and concentration disturbances) of the last two weeks and is presented on a four-point Likert scale (*0= not at all* to *3= nearly every day*). The severity of the depression can be derived from the total score (ranging from 0 to 27) and can be interpreted as follows: 1–4 none/minimal, 5–9 mild, 10–14 moderate, 15–19 moderately severe, and 20–27 severe depressive symptoms. A total of ≥ 11 indicates the presence of depression. Good internal consistency (Cronbach's $\alpha = 0.89/0.86$) and construct validity has been proven [24].

Generalized anxiety disorder scale-7. The Generalized Anxiety Disorder Scale-7 (GAD-7) is a self-report questionnaire to screen for generalized anxiety disorders and to assess its severity [25]. The GAD-7 consists of seven items referring to the last two weeks (e.g. feelings of nervousness, anxiety, and tension) and is based on a four-point Likert scale (*0= not at all* to *3= almost every day*). The total score ranges from 0 to 21 and can be interpreted as follows: 0–4 minimal, 5–9 mild, 10–14 moderate, and 15–21 severe anxiety symptoms. A cut off value of ≥ 10 is likely to represent a generalized anxiety disorder. Validity has been proven and the internal consistency (Cronbach's $\alpha = 0.92$) is reported to be good [24].

Biomedical parameter and risk factors. We used patient records to systematically track the general health status, possible risk factors and the most common (extra-) cardiac consequential diseases such as coronary heart disease, myocardial infarction, heart and renal failure, and cerebrovascular events [4–6]. Furthermore, we documented the initial systolic and diastolic BP (mostly measured on the ward, in single cases measured in the emergency room) and screened for antihypertensive medication. Regarding the risk factors for arterial hypertension, we noted height and weight, from which we calculated the body mass index (BMI) and classified it according to criteria set by the World Health Organization [26]. Nicotine consumption was reported as *'never smoked'*, *'former smoker'* or *'active smoker'*. Concerning alcohol consumption, participants could choose between *'none at all'*, *'1–2 glasses/drinks daily'*, and *'>2 glasses daily'* [1, 7].

Statistical analysis

Data entry was completed using the freely available GNU software PSPP and subsequent analyses were completed using IBM SPSS Statistics 23. Among a total of 215 participants, 186 had arterial hypertension, of whom 160 completed questionnaires and had their BP values recorded at baseline. We examined the cohort regarding biomedical, sociodemographic, and socioeconomic parameters. In terms of marital status, living alone included *'single'*, *'married living apart'*, *'divorced'* and *'widowed'*. *'Cohabiting married'* and *'cohabiting in partnership'* were summarized as living in partnership. We calculated the years of education from the indicated final school examination (or years of schooling) and professional qualification. The data on monthly net income were divided into three categories (*< 1 000 euros/month*, *1 000- 3 000 euros/month* and *> 3 000 euros/month*). The classification of BMI was completed according to the World Health Organization [26] and the categorization of BP according to the S3G [1]. We examined the overall cohort regarding the perceived benefit of the TA. For this purpose, in addition to absolute values, the mean values were calculated, resulting in rankings.

LCA was used to probabilistically group patients based on their evaluation of the S3G recommendations. The latent classes are defined as homogeneous subgroups with class-specific response patterns that result from interindividual differences in response characteristics. This statistical method offers an exploratory approach to our current, limited data and allows to simplify extensive data and improve the understanding of the underlying structures in a population [27]. The aim of this study was to identify latent classes in people with arterial hypertension regarding the

Table 1. Descriptive statistics in comparison.

	All Participants (N = 160)		Class 1 (n = 97)		Class 2 (n = 63)	
	Mean (SD)	**N (%)**	**Mean (SD)**	**n (%)**	**Mean (SD)**	**n (%)**
BP Medication		87 (54.4%)		56 (57.7%)		31 (49.2%)
CHD		117 (73.1%)		74 (76.3%)		43 (68.3%)
State after MI		34 (21.3%)		22 (22.7%)		12 (19%)
Heart Failure		53 (33%)		33 (34%)		20 (31.7%)
Mental Health						
PHQ Sum Score	7.56 (4.786)		7.11 (4.700)		8.274 (4.869)	
PHQ ≥ 11		44 (28%)		26 (27.1%)		18 (29%)
GAD Sum Score	4.89 (3.855)		4.57 (3.747)		5.397 (3.994)	
GAD ≥ 10		21 (13.1%)		12 (12.4%)		9 (14.3%)
BMI (kg/m^2)	28.55 (5.98)		28.7 (6.167)		28.36 (5.752)	
Normal Weight		36 (24.7%)		22 (25.3%)		14 (23.7%)
Overweight		58 (39.7%)		34 (39.1%)		24 (40.7%)
Obese (>30)		51 (35%)		30 (34.4%)		21 (35.6%)
Systolic BP	137 (23.732)		134 (2.510)		142 (2.908)	
Hypotension		3 (1.8%)		3 (3.1%)		–
Normotony		60 (37.5%)		40 (41.2%)		20 (31.8%)
High-Normal BP		27 (16.9%)		15 (15.5%)		12 (19%)
Hypertension Grade I		43 (26.9%)		28 (28.9%)		15 (23.8%)
Hypertension Grade II		19 (11.9%)		7 (7.2%)		12 (19%)
Hypertension Grade III		8 (5%)		4 (4.1%)		4 (6.4%)
Regular Alcohol Use[a]		18 (23.1%)		13 (31.7%)		5 (13.5%)
Nicotine Use[b]						
Current		20 (16.5%)		2 (3%)		18 (32.7%)
Former		52 (43%)		41 (62.1%)		11 (20%)
Never		49 (40.5%)		23 (34.8%)		26 (47.3%)

BP blood pressure, *CHD* Coronary Heart Disease, *MI* myocardial infarction, *BMI* body mass index, *PHQ* patient health questionnaire-9, *GAD* generalized anxiety disorder scale-7.
[a]Due to missing data, the sample size for this variable is reduced to N = 78 (class 1 n = 41, class 2 n = 37).
[b]Due to missing data, the sample size for this variable is reduced to N = 121 (class 1 n = 66, class 2 n = 55).

evaluation of the TA defined in the S3G. This should serve as a basis to develop targeted interventions or measures in the future, taking into account the group-specific needs identified here.

Prior to the LCA, we dichotomized the items by combining the lower and upper two categories (*did not help at all/helped a little* and *helped moderately/helped a lot*) based on previous research [28]. Thus, the nine LCA indicators represented the evaluation of the S3G recommendation as more or less helpful. For the LCA, we chose maximum likelihood estimation with robust standard errors, with variances held equal across classes and covariances among the latent class indicators fixed at zero. To reduce the risk of local maxima, the initial number of random starting value sets was set at.

In total, 1000, and the 100 best sets (according to their likelihood values) were selected for optimization after 100 iterations. Additionally, we entered the scale means of PHQ-9 and GAD-7 as well as systolic and diastolic BP measures as outcome variables to test for equality of means across classes using the 3-step procedure.

After conducting a series of successive latent class models with increasing numbers of latent classes, the decision regarding the number of obtained classes was based on conceptual reasons (interpretability of the class solution) as well as empirical evidence. Empirical evaluation included maximization of the log-likelihood value and entropy, Bootstrap Likelihood Ratio Tests and Vuong-Lo-Mendell-Rubin Tests to assess improvement in model fit and, in addition, minimization of the Akaike information criterion, Bayesian information criterion and sample size-adjusted Bayesian criterion to control for model complexity [27]. We used Mplus version 8.3 [27] to perform the LCA and IBM SPSS Statistics version 28 for all further analyses.

RESULTS

Participants

Our study included 160 participants, 44% of whom identified as women and 56% as men. The average age was 72 years. The respondents had on average two children, 14 years of education, more than 50% lived in a partnership and almost 80% were already retired while less than a third were working. The majority reported a net income of 1 000 to 3 000 Euros. There were no statistically significant class differences regarding the socio-demographic parameters. Roughly one third of participants indicated a mental health condition (depression as assessed on the PHQ-9). The average systolic blood pressure of the overall cohort was 137 mmHg (mean class 1: 134 mmHg, mean class 2: 142 mmHg). Furthermore, cardiological (secondary) diseases (coronary heart disease and/or heart failure, myocardial infarction) were surveyed, for which no statistically significant class differences were found. Table 1 shows the medical data on BP, secondary diseases, and the risk factors of arterial hypertension for the overall cohort and in class comparison.

Latent class analysis

The detailed results for the increasing latent class models in terms of model fit indices are presented in Table 2. The Bayesian information criterion value, recommended to determine the number of latent classes [28], was lowest for the 2-class solution.

Table 2. Latent class model fit.

Model	FP	Log-likelihood	Entropy	AIC	BIC	aBIC	BLRT *p* value	VLMRT *p* value
1-class	9	−790,723	–	1599.446	1627.123	1598.632	–	–
2-class	**19**	**−732,470**	**0.891**	**1502.940**	**1561.368**	**1501.221**	**0.0000*****	**0.0000*****
3-class	29	−720,546	0.913	1499.092	1588.272	1496.469	0.0900	0.2315
4-class	39	−711,259	0.950	1500.518	1620.449	1496.990	0.3400	0.0379*
5-class	49	−701,929	0.822	1501.859	1652.542	1497.426	0.2800	0.2219

The best fit model is shown in bold. FP = number of free parameters.
AIC Akaike information criterion, *BIC* Bayesian information criterion, *aBIC* sample size-adjusted BIC, *BLRT* Bootstrap Likelihood Ratio Test *p* value for (k-1) classes, *VLMRT* Vuong-Lo-Mendell-Rubin Likelihood Ratio Test *p* value for (k-1) classes.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

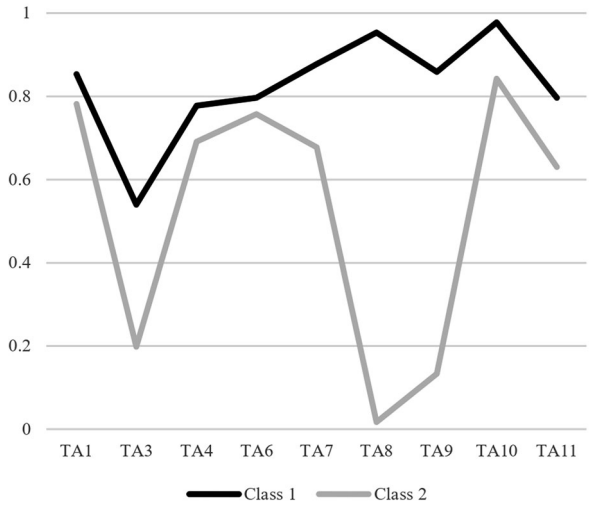

Fig. 1 Response patterns of the 2-class model. TA Therapeutic Approach, TA1 Medication, TA3 Weight Loss, TA4 Bloodpressure Control, TA6 Conversations with Doctors, TA7 Healthy Diet, TA8 Nicotine Use Cessation, TA9 Alcohol Use Cessation, TA10 Family/ Social Support, TA11 Stress Reduction.

In comparison to the 1-class model, the Bootstrap Likelihood Ratio Test and Vuong-Lo-Mendell-Rubin Likelihood Ratio Test both indicated a better fit for the 2-class model which also exhibited an adequate entropy value. We selected the 2-class model to represent our data due to its superior statistical and conceptual fit.

Comparison of the two latent classes

Figure 1 displays the response patterns of the two latent classes. Differences in the response patterns between the classes are evident regarding three TA: In class 2 ($n = 63$, i.e. 39% of our sample), item/TA 3 (weight reduction), item/TA 8 (nicotine renounce) and item/TA 9 (alcohol renounce) were experienced as less effective. Participants in class 1 ($n = 97$, i.e. 61%) experienced all offered TA helpful. Outcome parameters studied were BP, sex, years of education, BMI, depression (PHQ-9), and anxiety (GAD-7). The two latent classes differ regarding their systolic BP, X^2 (1) = 3905, $p = 0.048$. The average BP of class 1 is in the range of high-normal BP (mean 134 mmHg) and for class 2 it is in the range of mild hypertension (Grade 1, mean 142 mmHg), see Table 1.

We further examined the evaluation of TA independent of classes, with family/social support (item/ TA10) reported to be the most effective approach (*mean 3.66*), followed by medication (item/TA1, *mean 3.23*), conversations with doctor (item/TA6, *mean 3.2*) and healthy diet (item/TA7, *mean 3.2*). For evaluation in absolute values see Fig. 2.

DISCUSSION

SUMMARY

As most past studies have focused on medication adherence [15], in this exploratory study, we used a LCA to identify patterns regarding perceived effectiveness of TA (focusing lifestyle changes) lined out within S3G recommendations in patients with arterial hypertension. We assumed that latent classes exist concerning the perceived effectiveness of TA, and that these classes differ regarding their baseline BP. Furthermore, we assumed that their differences likely occur in respect referring to sociodemographic variables, risk factor profile, and psychopathological findings.

Two latent classes could be identified based on the response patterns. These classes differed in their systolic BP. Class 1 tended to perceive all recommended TA as helpful and reflected individuals with high-normal BP. Class 2 tended to view recommendations regarding weight reduction, and cessation of nicotine and alcohol use, as less effective and included those with mild hypertension. There were no statistically significant class differences regarding the sociodemographic parameters, risk factors or psychometric questionnaires. We further examined the patients' perceptions of TA independent of classes, with family and/or social support reported to be the most effective intervention.

DISCUSSION OF THE RESULTS

Our overall sample reflects the population with arterial hypertension in Germany in the most relevant respects: For example, our average participant age (72 years) reflects the age group most afflicted with arterial hypertension (65–79 years) [2]. There were no statistically significant class differences regarding the sociodemographic sample characteristics and cardiological (secondary) diseases such as coronary heart disease, heart failure and/or myocardial infarction. The evaluation of the PHQ-9 in our overall cohort shows a significantly higher depression rate of about 1/3 compared to the German average (prevalence 9.2%) without any statistically significant class differences. A closer look at the European Health Interview Survey (EHIS) 2 shows an even lower prevalence of 6.7% among the elderly population [29]. Comparability is given as the cut-off score for the presence of depression in the PHQ-8 (≥10 points) and PHQ-9 (≥11 points) is almost identical [24, 29].

The Robert Koch Colloquium points out that the main risk factors for hypertension (including physical inactivity, obesity, unhealthy diet, stress, increased alcohol consumption) are modifiable, resulting in high potential for prevention [7], which is reflected in this study by the different response patterns and BP values: Class 1 tend to experience all offered TA as helpful, while Class 2 evaluated weight reduction, nicotine and alcohol use

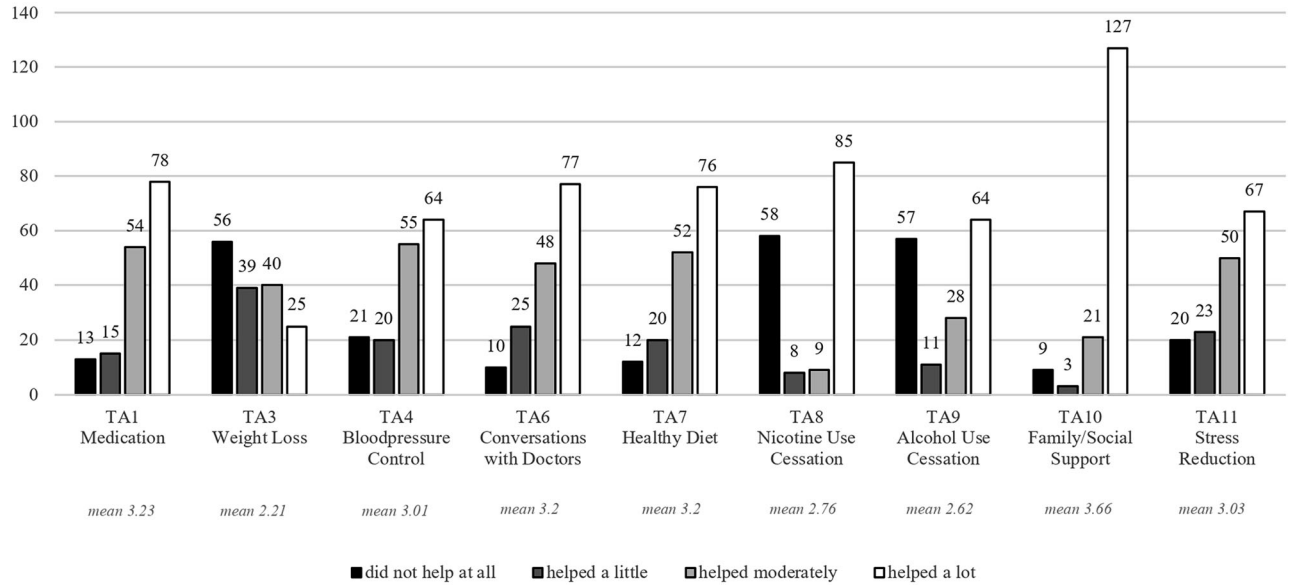

Fig. 2 Evaluation of S3 guideline recommendations. TA Therapeutic Approach.

cessation as less effective. Those with high-normal BP are represented in Class 1 and those with mild hypertension (Grade 1) constituted our second class. As some papers show a positive linear association between alcohol consumption, BP and the prevalence of hypertension [30], it can be hypothesized that some patients in our study have higher BP because they do not experience weight, nicotine and alcohol use cessation as helpful and therefore do not implement them. This is illustrated as there are significantly more smokers in our second class. The average BMI of the participants in this study is 28.6 kg/m^2, which is above the recommended 'healthy BMI' (20–25 kg/m^2) of the S3G [1]. However, another study shows that nicotine consumption and body weight do not have a significant influence on vascular mortality [6].

As in relation to the guideline, the systolic BP values recorded can be classified as being within the target range for class 1 (mean 137 mmHg) and an approximation to it can be determined for class 2 (mean 142 mmHg). The BP difference between the two classes of 8 mmHg is associated with a substantial risk reduction of secondary diseases. Various studies show a general reduction of at least 10 mmHg is associated with a reduced all-cause mortality [6, 10]. Lewington et al. even assume reduced all-cause mortality from a 2 mmHg reduction [6]. In the literature, there are varying data on the BP threshold value for significant risk reduction. Bundy et al. emphasize that although the majority of secondary diseases occur at mild hypertension (systolic BP > 140 mmHg), about 30% can already be observed between 115 and 140 mmHg [11], others could not identify a significant risk reduction below 130 mmHg [6, 10]. The S3G recommends antihypertensive treatment by lifestyle modification from > 130 mmHg and additional drug treatment from > 140 mmHg due to the increased risk for secondary diseases [1].

In this study, the terms adherence and compliance are intentionally distinguished from each other. It can be assumed that the evaluation of the TA has an influence on the adherence and effectiveness of the antihypertensive therapy. Vermeire et al. were already able to demonstrate the correlation between compliance and patients' own beliefs, which are influenced by personal knowledge and experience [13]. Furthermore, it should be considered that about 1/3 of the participants achieved a PHQ score ≥ 11, which indicates the presence of depression [24] and, according to other studies, is associated not only with reduced quality of life but also with low treatment compliance [14, 31]. Studies show a high correlation between chronic diseases and psychological phenomena such as anxiety and depression [14, 23]. Bosworth et al. already demonstrated the complexity and diversity of low adherence by identifying more than hundred factors as potential predictors [22]. Age is consistently identified as a factor which influences adherence [19] and the amount of affected people rises congruently with age (about 70% are between 65 and 79 years old) [2]. In their study, Vermeire et al. already highlighted the difficulties especially among elderly patients (with cognitive deficits) to implement rather complex instructions [13]. Accordingly, it is relevant to highlight the proven importance of social support [14, 19], which is also reflected in our study. Regardless of the latent classes, this TA was experienced as the most relevant. More than half of the participants in our study were living together in partnership or marriage. However, in this context it should be critically questioned whether the cohabitation or the person(s) is/are experienced as supportive and to what extent a sustainable doctor-patient-relationship can provide compensation as it is one of the most commonly recommended ways to improve compliance [32]. Based on a concept of adherence as patient-centered and collaborative relationship between doctor and patient, the fact that the latter also has the right to refuse recommended treatments should not be disregarded. The intentional refusal or reduction of medication intake because of occurring side effects, incorrect diagnoses, or insufficient effects, is rationally understandable, however nonetheless it is considered non-compliant [33]. Most studies focus on patient non-adherence and neglect poor communication skills on the physician's side [13] although it is already known that not only improving patient-centeredness but rather also the accurate recognition of the patient's problem by the doctor improves compliance [32].

LIMITATIONS

Certain limitations should be considered when interpreting our study findings. First, BP values were collected at an undefined time during the entire treatment; comparative values before the hospital treatment were not documented given the cross-sectional study design. For better comparability between the participants, we documented the BP measured first during hospital treatment, mostly on the ward and in single cases in the emergency room. Second, it should be considered that the diagnosis and treatment of arterial hypertension usually takes

place in an outpatient setting. The participants in this study were undergoing inpatient cardiological treatment, and the initial admission diagnosis was not clearly documented. In accordance with the inclusion criteria, hypertension was already diagnosed in a prior outpatient setting and treatment was initiated. Our questionnaire primarily refers to this, which makes the inpatient treatment that took place at the time of the survey insignificant. Third, we considered systolic BP in isolation and neglected the diastolic value, which in turn excluded diastolic hypertension. In this regard, White et al. showed that the systolic BP is more informative than the diastolic BP if a single measurement is used for risk prediction [34]. Fourth, the effectiveness of the TA was assessed by means of a self-developed, non-validated questionnaire. However, it was strictly based on the S3G and supplemented by further relevant influencing variables, thus compensating for a lack of questionnaires within this research stream. Focusing adherence there is currently no adequate method of measurement due to inconsistent terminology and different methods, such as more accurate direct (e.g. blood tests) and less confidential indirect measurements (e.g. counting tablets, BP, body weight). Self-reports and physician assessments carry the risk of over- and underestimation [13]. Fifth, we incurred many missing datapoints regarding our participants' alcohol and nicotine consumption. These are unsystematic missings due to the lack of information in the admission and discharge reports. This problem could already be identified during the survey phase and compensated for by directly questioning our later participants. Furthermore, it was not ascertained which TA were implemented or at least tried. It is unclear how non-smokers rated abstinence from nicotine, since every answer (*'did not help at all'* to *'helped a lot'*) would be comprehensible; the same applies to those who have never consumed alcohol. Sixth, this study speaks of adherence, although the treatment planning process could not be traced due to the study design.

CONCLUSION

In this study, we identified two latent classes concerning perceived effectiveness of the TA outlined within the S3G recommendations. The classes vary in their evaluations of three TA (weight reduction, alcohol and nicotine use cessation) and differ in terms of their systolic BP by 8 mmHg. There were no statistically significant differences regarding sociodemographic variables, risk factor profile, or psychopathological findings. The analysis of the perceptions of TA's independent of the classes indicated family and/or social support to be the most essential approach. It is not possible to infer a causal relationship between perceived effectiveness and BP differences from our study findings. Nonetheless, it can be assumed that perceptions of the TA have an influence on the adherence and effectiveness of the antihypertensive therapy. As the threshold and concrete BP difference for risk reduction are controversial, the focus should be on the individual benefit rather than reducing risk factors and BP to a certain threshold. This makes patient-centered treatment planning even more important: Concepts such as shared decision-making are indispensable in this context and should be seen as a precondition for the effectiveness of the recommended TA. In turn, individual needs can be recognized and adequately balanced with treatment goals. With these findings in mind, assessing perceived effectiveness of the TA recommended in arterial hypertension's S3G should be considered in treatment planning. Future research studies should focus on the patient's individual situation and aligning therapy concepts based on their circumstances and unique profiles. The effectiveness of the therapy must also be assessed in longitudinal studies with larger and more robust study cohorts. Lastly, valid measurement methods should be developed to better identify and support non-adherent individuals.

SUMMARY

What is known about the topic?

- Despite therapeutic measures, blood pressure remains in the hypertensive range in about half of those affected in Germany, predominantly in the range of hypertension grade 1.
- Antihypertensive medication and lifestyle adherence can significantly reduce the risk of cardiovascular diseases and all-cause mortality within an optimal blood pressure.
- Lifestyle changes achieve effects equivalent to medication. However, there is evidence of discrepancies between the S3 guideline's recommendations and its implementation in patients' lives, indicating low adherence.

What this study adds

- Latent classes could be identified in people with arterial hypertension.
- People with persistent, mild hypertension (Grade 1) do not experience positive outcomes from weight reduction or the cessation of alcohol and nicotine use. These may explain why these therapy approaches are often not implemented by this group.
- The perceived efficacy of the S3 guideline's therapeutic approaches may influence patient adherence and perceived effectiveness of the antihypertensive therapy. This makes patient-centered treatment planning even more essential and highlights the importance of shared decision-making in secondary prevention.

DATA AVAILABILITY

On request the raw data will be made available by the authors without reservation.

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AUTHOR CONTRIBUTIONS

JS: Conceptualization, Methodology, Data curation, investigation, Formal analysis, Resources, Writing, Review & Editing. NO: Formal analysis, Resources, Writing. AH: Data curation, investigation. GO'M: Review & Editing. TS*: Conceptualization, Methodology, Supervision, Review & Editing. KH*: Conceptualization, Methodology, Supervision, Review & Editing. (*These senior authors contributed equally to this work).

COMPETING INTERESTS

The authors declare no competing interests.

ETHICAL APPROVAL

The ethics application was approved by the Ethics Committee of the Brandenburg Theodor Fontane Medical School (MHB) on March 18, 2019 (Reference number: E-01-20190111). Extension of the study was further approved by the Committee on December 04, 2019. All methods were performed in accordance with relevant guidelines and regulations.

ADDITIONAL INFORMATION

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