Brazilian Dysphonia Screening Tool (Br-DST): An Instrument Based on Voice Self-Assessment Items

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Summary: Objective. To propose a short instrument for the screening of dysphonia in the Brazilian population through the investigation of traditional voice self-assessment instrument items.

Methods. We analyzed the medical records of 139 individuals with an average age of 37.4 years and a minimum and maximum age of 18 and 77 years, respectively. The participants were classified as dysphonic (D) or non-dysphonic (ND) according to an analysis of the combination of vocal complaints and laryngological reports. Responses to the items of the following self-assessment instruments were collected: the *Questionário de Qualidade de Vida em Voz − QVV* (Voice-Related Quality of Life − V-RQOL), the *Índice de Desvantagem Vocal − IDV* (Voice Handicap Index − VHI) and the *Escala de Sintomas Vocais − ESV* (Voice Symptom Scale − VoiSS). These items were analyzed regarding their predictive capacities for dysphonia through logistic regression models.

Results. The model containing items of the QVV was not observed to be valid. The model for the IDV produced a set of three items (10, 13, and 14), and the ESV model showed two items (4 and 20) to be significant. A Global model combining the previous models shows that items "I feel I have to force my speech" from the IDV and "Is your voice hoarse?" from the ESV are the most significant in the classification of the presence of dysphonia. This decision-making model was considered the most efficient to identify the dysphonia, with the highest level of accuracy compared to the other models investigated (83.4%).

Conclusion. Dysphonia screening can be performed using a simple, rapid protocol with a high-efficiency index that includes two items taken from traditional voice self-assessment instruments.

Key Words: Clinical protocols−Dysphonia−Outcome assessment−Regression analysis−Self-assessment−Voice.

INTRODUCTION

Dysphonia has been determined to be an increasingly comprehensive disorder, given its impacts on affected individuals' lives. In addition to the inherent physiological dysfunctions that compromise oral communication, other problems are often observed, such as social isolation, low self-esteem, depression, low overall quality of life, and absenteeism at work.[1−4]

The etiologies of dysphonia are diverse, but they can be categorized, in a simple and didactic way, into two large groups, behavioral and organic dysphonia. Behavioral disorders are related, to a greater or lesser extent, to inadequate or excessive voice use associated with the presence or absence of structural changes in the vocal folds. On the other hand, organic conditions have no direct relationship to the use of voice and result from endocrinological or laryngeal cancer, for example.[5, 6]

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Considering these aspects, in addition to a prevalence that varies from 3% to 10% in the general population and that can reach up to 50% in voice professionals,[1,7] diverse researchers have been dedicated to the study and development of increasingly efficient mechanisms for the screening, evaluation, and intervention of this disorder, especially considering that an early diagnosis favors treatment and reduces costs to the public.[8−10]

Dysphonia, defined as any difficulty or deviation in voice production that limits communication or has a negative impact on an individual's quality of life,[6] manifests through symptoms and/or varied sensations: deviations in quality, frequency and/or voice intensity; low voice resistance; effort and/or tiredness when speaking; discomfort or unpleasant sensations at emission; among others.[11, 12] Therefore, the evaluation of a voice disorder, from the perspective of the individual who faces it, is a unique and essential resource for voice diagnosis that is impossible to assess with any other evaluation approach.

The self-assessment instruments are recurrent and reliable strategies for tracking health conditions in the population, especially through epidemiological surveys. They have been considered robust means to assess the impact of a health condition on individual well-being.[13] Such tools are also simple and cost-effective, do not require specific collection conditions, and are not dependent on the examiner's experience.

Several instruments for the self-assessment of the impact of a voice problem have gained popularity in voice clinics, with scientific studies recognizing their contributions in the evaluation and management of patients. Some instruments already employ cutoff points based on criteria of sensitivity and statistical specificity for the discrimination of individuals with or without dysphonia.[14] However, given the many options available and the diversity of information available for each instrument, choosing the best instrument for clinical and epidemiological use in identifying dysphonia is a difficult task to be performed, especially in situations where individuals are not submitted to a complete voice evaluation.

In regular speech-language pathology consultations where the clinician performs a speech-language pathology voice evaluation, with anamnesis, the auditory perceptual evaluation of voice quality, and the extraction of behavioral to acoustic measures, an instrument can be selected to investigate a specific aspect to be explored.[6]

However, when the voice self-assessment is the starting point or when this is the only resource available for a preliminary assessment of possible dysphonia, identifying certain flaws of psychometric structure[15, 16] requires that some properties of such instruments be scientifically reanalyzed. In general, each protocol proposes to evaluate a certain number of items to produce a single score without specifically knowing the relationships between each of the items and the presence of dysphonia or even without considering a possible overlapping of content addressed by the items.

Such information is relevant because determining the intensity of the associations between the items and dysphonia's presence leads to the identification of aspects that must be considered "more important" in the analysis of the instrument's results. This result can reduce items to be investigated, which allows dysphonia to be tracked quickly and efficiently.

Tracking involves simply, inexpensively, and quickly detecting a probable disease or injury in any individual, followed by a referral for diagnostic confirmation and treatment.[13] Screening procedures are typically used to identify individuals affected by a disease within a population in order to direct only those selected toward more complex diagnostic procedures. As voice assessment is a complex and multidimensional process requiring various types of analyses, in addition to a knowledgeable and experienced examiner,[17−19] it is desirable to seek a shorter and simpler mechanism for dysphonia screening that addresses only that information considered closely related to the presence of this disorder for use in actions involving a large number of participants.

The voice self-assessment questionnaires seem to be useful tools for this purpose, but investigating their items more related to the presence of dysphonia is necessary for the establishment of a shorter and more efficient instrument. Thus, this research aimed to propose a short instrument for dysphonia screening in the Brazilian population based on the investigation of items of traditional voice self-assessment instruments.

METHODS

We conducted a retrospective and cross-sectional research study evaluated and approved by the Research Committee of the Institution of Origin (Health Sciences Center of the Universidade Federal da Paraíba − UFPB) under opinion number 0482/15. Data were extracted from a digital database of the voice laboratory of a higher education institution containing personal data and medical records of patients assisted by the institution's voice care services. Of the patients with available registration, individuals over the age of 18 presented information on voice complaints and laryngeal diagnoses. They answered all items of the self-assessment questionnaires considered in the study.

As a result, 139 individuals with an average age of 37.4 years and minimum and maximum ages of 18 and 77 years, respectively, participated. Most of the participants were female (72.7%, n = 101) and non-voice professionals (63.3%, n = 88). More dysphonic (63.3%, n = 88) than non-dysphonic (ND) patients (36.7%, n = 51) participated, and the most frequent laryngeal conditions included lesions in the membranous portion of the vocal fold (nodules, polyps, grooves and cysts) (40.3%, n = 56); muscle tension dysphonia and functional glottic clefts (13.7%, n = 19); signs of gastroesophageal reflux, laryngitis, corditis, edema, hyperemia (7.9%, n = 11); and neurological dysfunctions (Parkinson's disease and vocal fold paralysis) (1.4%, n = 2).

For registration in the database, patients' laryngeal diagnosis was established based on laryngological reports with or without laryngeal, structural or functional disorders. Participants who presented voice complaints associated with altered laryngological reports were classified as dysphonic (D). Those who did not manifest voice complaints and presented laryngological reports without alterations were classified as ND, constituting the control group. Then, dysphonia's presence or absence was established from the sum of two variables: voice complaint and laryngological diagnosis.

The following self-assessment instruments were selected as data collection instruments for this study: the *Questionário de Qualidade de Vida em Voz − QVV* (translated, adapted and validated version for the Brazilian Portuguese of the instrument Voice-related Quality of Life − V-RQOL),[20,21] which assesses the voice-related quality of life; the *Índice de Desvantagem Vocal − IDV* (translated, adapted, and validated version for the Brazilian Portuguese of the instrument Voice Handicap Index − VHI),[20,22] which measures the disadvantage that voice disorders can bring to an individual's life; and the *Escala de Sintomas Vocais − ESV* (translated, adapted and validated version for the Brazilian Portuguese of the instrument Voice Symptoms Scale − VoiSS),[23,24] which assesses self-perceptions of voice symptoms and the impacts of voice problems. These three voice self-assessment instruments were selected among the various currently available options because these instruments have been validated in several languages and have been widely used in several countries.

Also, these instruments have other reasons for being selected. VHI and V-RQOL, original versions of the Brazilian instruments IDV and QVV, were the first voice self-assessment instruments to have their validations published in the scientific literature[21, 22] and since then represent the most widely referenced questionnaires internationally. VoiSS, the original version of the Brazilian instrument ESV, in turn, is considered the most robust and widely validated psychometrically voice self-assessment instrument currently available, with a high degree of validity, reliability, and responsiveness to voice changes.[15;23]

The three instruments were developed to be answered by the patient on *Likert* response scales with five graduation points. The IDV has 30 items divided into three domains (emotional, physical, and organic), and the ESV also has 30 items divided into three domains (limitation, emotional, and physical). Both are scored based on a simple sum of answers obtained on all items, ranging from 0 to 120 points. For the IDV, the higher the result is, worse the disadvantage perceived by the individual, and for the ESV, the higher the score is, stronger the perception of the voice deviation reported by the patient. The cutoff points established to indicate dysphonia in the Brazilian population are 19 points for the total IDV score and 16 points for the total ESV score.[14]

The QVV has 10 items divided into two domains, socioemotional and physical. Its interpretation indicates that the higher the score produced, the higher the level of voice-related quality of life. Notably, the QVV instrument is the only instrument that uses the proposed calculation for instruments that analyze life quality to obtain its total scores and domains. The cutoff point established to indicate dysphonia in the Brazilian population for the total score is 91.25 points.[14]

After accessing the database, applying eligibility criteria, and collecting all available information, a careful analysis of the data was performed to detect possible typos or missing data. Then, all variables for statistical treatment were codified.

A logistic regression model was used as a data analysis method to estimate, based on a mathematical function, the probability of an event of interest (dependent variable) based on the behavior of a set of factors (independent variables) and to assess the existence of a possible statistical dependence relationship between them.[25]

For the adjustment of the logistic regression models, the presence of dysphonia (D) was defined as a dependent variable, with response 0 (no) or 1 (yes), and all items from the three self-assessment instruments evaluated here (QVV, IDV, and ESV) were defined as independent variables. Due to many items available (total = 70 items), a preselection of items was performed using the chi-square association test with a high significance level (α = 0.10). Only variables (items) showing statistical significance in the association with dysphonia in this first stage were considered eligible for regression analysis.

Then, the logistic regression models were adjusted for each question by estimating parameters for the items selected. A significance level of α = 0.05 was adopted to exclude variables considered nonsignificant in this stage of the analysis. Thus, we obtained a dysphonia prediction model for each questionnaire to select only the most significant items. A fourth model, the global model, was developed by considering the items remaining in the final models of the three self-assessment questionnaires. The same procedure for the elimination of nonsignificant variables was applied at a significance level of 0.05.

An evaluation of all adjustments' validity and quality was performed using the deviation and ROC curve function. The odds ratio (OR) was estimated to better interpret the parameters of the models obtained. The sensitivity, specificity, and accuracy indexes of the four models created were compared to identify the one with the best predictions and the best efficiency indexes for the classification of dysphonia. The objective was to verify whether the global model could be considered the best decision instrument to classify individuals and track the dysphonia.

To evaluate the actual performance and efficacy of the investigated models, a cross-validation process was performed. This technique involves the random division of the dataset available into mutually exclusive subsets, which are then used for the estimation of parameters (training set) and the validation of the estimated model (validation or test set). This process is performed k times to vary the datasets without repetition. After k combinations are evaluated, the model's accuracy is calculated based on the average of the errors and correct answers found in all tests (hit rate) to obtain a reliable measure of the classification capacity of the model[26] and the best decision-making model.

After selecting the best model, probabilities were calculated to facilitate its interpretation and applicability. From the estimates of the logistic regression model's parameters, it was possible to simulate all possible response options and estimate the probability of dysphonia occurrence for each case.

All statistical analyses were performed using R version 3.5.1 software.

RESULTS

We first preselected the items most associated with the presence of dysphonia for each questionnaire using the association chi-square test (α = 0.10) (Table 1). With this smaller group of items, the regression models' adjustment was initiated for each of the investigated questionnaires.

Adjustments of regression models

The details of the models obtained, including estimates of the parameters β's and analyses of the deviation function (RD), ORs, and confidence intervals (CIs), were analyzed (Table 2).

The model obtained for the QVV instrument presented only one significant variable: "9. *Tenho que repetir o que falo para ser compreendido* (I have to repeat what I say to be understood)". According to the results, a positive response to this question implies a 2.5-fold higher chance of an individual presenting dysphonia (CI = 1.2; 5.4). However, this

TABLE 1.
Items of Each Voice Self-Assessment Questionnaire Most Associated With Dysphonia and Their Respective *P* Values

Questionnaire	Item	*P* Value*
QVV	1) *Tenho dificuldades em falar forte (alto) ou ser ouvido em lugares barulhentos* (I have trouble speaking loudly or being heard in noisy places)	0.008
	2) *O ar acaba rápido e preciso respirar muitas vezes enquanto eu falo* (I run out of air fast and I need to breathe many times while I speak)	0.008
	6) *Tenho dificuldades em falar ao telefone (por causa da minha voz)* (I have trouble talking on the phone (because of my voice))	0.044
	9) T*enho que repetir o que falo para ser compreendido* (I often must repeat what I say to be understood)	0.021
IDV	2) *Fico se mar quando falo* (Irun out of air when I talk)	0.056
	4) *Minha voz varia ao longo do dia* (My voice varies throughout the day)	<0.001
	5) *Minha família tem dificuldade em me ouvir quando os chamo de um outro cômodo da casa* (My family members have difficulty hearing me when I call them from another room in the house)	0.073
	6) *Uso menos o telefone do que eu gostaria* (Use the phone less than I would like)	0.044
	7) *Fico tenso quando falo com os outros por causa da minha voz* (I become tense when I talk to others because of my voice)	0.087
	10) *As pessoas perguntam: "O que você tem na voz?"* (People ask me, "Is something obstructing your voice?")	<0.001
	11) *Falo menos com amigos, vizinhos e parentes por causa da minha voz* (I talk less with friends, neighbors and relatives because of my voice)	0.076
	12) *As pessoas pedem para eu repetir o que falo quando conversamos pessoalmente* (People ask me to repeat what I say when we talk in person)	<0.001
	13) *Minha voz parece rouca e seca* (My voice seems hoarse and dry)	<0.001
	14) *Sinto que tenho que fazer força para a minha voz* sair (I feel like I have to force my speech)	<0.001
	15) *Acho que as pessoas não entendem o meu problema de voz* (I don't think people understand my voice problem)	<0.001
	17) *Não consigo prever quando minha voz vai sair clara* (I can't predict when my voice will come out clear)	0.056
	20) *Faço muito esforço para falar* (I exert a lot of effort to talk)	0.001
	21) *Minha voz é pior no final do dia* (My voice is worse at the end of the day)	0.001
	24) *Fiquei menos expansivo por causa do meu problema de voz* (My life is limited by my voice problem)	0.063
	25) *Minha voz faz com que eu me sinta em desvantagem* (My voice makes me feel at a disadvantage)	0.056
	26) *Minha voz falha no meio da fala* (My voice fails while I speak)	0.005
ESV	2) *Você tem dificuldades para cantar?* (Do you have trouble singing?)	0.020
	3) *Sua garganta dói?* (Does your throat hurt?)	<0.001
	4) *Sua voz é rouca?* (Is your voice hoarse?)	<0.001
	7) *Você tosse ou pigarreia?* (Do you cough or clear your throat?)	0.036
	9) *Você tem dificuldades para falar ao telefone?* (Do you have trouble talking on the phone?)	0.059
	11) *Você sente alguma coisa parada na garganta?* (You feel anything obstructing your throat?)	<0.001
	12) *Você tem nódulos inchados no pescoço?* (Do you have swollen nodules on your neck?)	0.076
	14) *Você se cansa para falar?* (Do you get tired of talking?)	0.091
	15) *Seu problema de voz deixa você estressado ou nervoso?* (Does your voice problem leave you stressed or nervous?)	0.007
	17) *É difícil falar forte (alto) ou gritar?* (Is it difficult to speak loudly or scream?)	0.003
	19) *Você tem muita secreção ou pigarro na garganta?* (You produce high volumes of secretions or phlegm in your throat?)	0.002
	20) *O som da sua voz muda durante o dia?* (Does the sound of your voice change throughout the day?)	<0.001
	23) *As pessoas perguntam o que você tem na voz?* (Do people ask you if you have something obstructing your throat?)	<0.001
	24) *Sua voz parece rouca e seca?* (Does your voice sound hoarse and dry?)	<0.001
	25) *Você tem que fazer força para falar?* (Do you have to force your speech?)	0.034
	27) *Sua voz falha no meio das frases?* (Does your voice fail while you are speaking?)	<0.001

* Values significant at $\alpha = 0.10$. Chi-square Test.
Abbreviations: QVV, *Questionário de Qualidade de Vida em Voz*; IDV, *Índice de Desvantagem Vocal*; ESV, *Escala de Sintomas Vocais*.

TABLE 2.
Description of Models Obtained for the QVV, IDV, ESV and Global Model in Terms of Independent Variables, Estimates of Parameters β's, Odds Ratios and Confidence Intervals

Model	Explanatory Variable	Parameter	Error - Default	*P* Value	OR	IC (OR)	RD	X^2
QVV	Intercept	0.1957	0.2219	0.882	-	-	176.5	165.3
	Item 9	0.9264	0.3794	0.0146	2.5	[1.22; 5.44]		
IDV	Intercept	−0.9609	0.3211	0.0028	-	-	143.1	163.1
	Item 10	1.0094	0.4576	0.0274	2.7	[1.12; 6.82]		
	Item 13	1.0869	0.4840	0.0247	2.9	[1.14; 7.73]		
	Item 14	0.9436	0.4971	0.058*	2.6	[1.14; 5.81]		
ESV	Intercept	−1.5163	0.4024	0.0002	-	-	131.7	164.2
	Item 4	2.4308	0.4589	0.0000	11.4	[4.75; 28.99]		
	Item 20	0.9467	0.4494	0.0352	2.6	[1.06; 6.23]		
Global	Intercept	−1.5543	0.3926	0.0000	-	-	127.4	164.2
	Item 14	1.3329	0.4534	0.0033	3.8	[1.57; 9.38]		
	Item 4	2.3357	0.4625	0.0000	10.3	[4.28; 26.49]		

* Significant value at level α = 0.06.
Abbreviations: QVV, *Questionário de Qualidade de Vida em Voz*; IDV, *Índice de Desvantagem Vocal*; ESV, *Escala de Sintomas Vocais*; OR, odds ratio; CI, confidence interval; RD, *residual deviance*.
Values significant at α = 0.05.

adjustment was considered invalid based on analysis of the deviation function, which presented a value higher than the chi-square statistic (RD = 176.5 > χ^2 = 165.3) and indicated that this model cannot be considered adequate for the data (Table 2). Therefore, the QVV instrument was removed from the analysis.

The regression model for the IDV shows that three of the 30 items are considered more significant for the classification of the presence of dysphonia. According to the OR estimates, those who answer "yes" to items "*As pessoas perguntam: 'O que você tem na voz?* (People ask me: 'Is something obstructing your voice?')", "*Minha voz parece rouca e seca* (My voice seems hoarse and dry)" and "*Sinto que tenho que fazer força para a minha voz sair* (I feel I have to force my speech)" (items 10, 13, and 14, respectively), with values of 2.74, 2.97, and 2.57, respectively, are more likely to have dysphonia than those who answer "no" (Table 2). Notably, item 14 remained in the model and even showed a *P*-value slightly above the established value (α = 0.05) for the theoretical relevance of the item investigated. Our evaluation of the model's validity shows that model 2 is adequate for the classification of the presence of dysphonia, as the value of the deviation was lower than that obtained for the chi-square statistic (RD = 143.1 < χ^2 = 163.2).

The model analyzing the ESV items shows that items "4. *Sua voz é rouca?* (Is your voice hoarse?)" and "20. *O som da sua voz muda durante o dia?* (Does the sound of your voice change throughout the day?)" are most significantly to classify the presence of dysphonia. Estimates indicate that individuals who answer "yes" to these items 11.4 and 2.6 times more likely to present dysphonia, respectively, than those who answer "no" (Table 2). The model was validated through an analysis of the deviation function (RD = 131.7 < χ^2=164.2).

The Global model, adjusted through the inclusion of all items contained in the previous models, produced a structure with two variables: item 14 of the IDV "*Sinto que tenho que fazer força para a minha voz sair* (I feel I have to force my speech") and item 4 of the ESV "*Sua voz é rouca?* (Is your voice hoarse?)". According to the OR values, individuals who answered "yes" to these items were, respectively, 3.8 and 10.3 more likely to have dysphonia than those who answered "no" (Table 2). This model was also validated by analyzing the deviation function (RD = 127.4 < χ^2 = 164.2).

Diagnostic evaluation and analysis of the generalization capacity of the s models (cross-validation)

An evaluation of the investigated models' sensitivity, specificity, and accuracy was performed by ROC curve analysis (Figure 1). The model for the IDV presented an accuracy of 80.2%, a specificity value of 80.4%, and a sensitivity value of 73.9%. The ESV model presented better accuracy (81.9%) and sensitivity (87.5%) and lower specificity (68.6%) than the previous model. The Global model, in turn, had the highest accuracy index (83.4%), sensitivity (87.5%), and specificity values (68.6%), similar to those of the ESV model.

Cross-validation analysis was used to verify the models' generalization capacity and assist in selecting the most efficient model (Table 3). A high mean rate of correct answers was observed for the test set data, that is, for data from the sample not used to estimate the parameters of the model, for all models. However, the IDV and Global models showed higher correctness rates for "new data" (84.3%).

Measures used for the interpretation of models

From the evaluation of sensitivity and diagnostic accuracy and the cross-validation test results, the Global model was selected as the best decision-making model to classify the

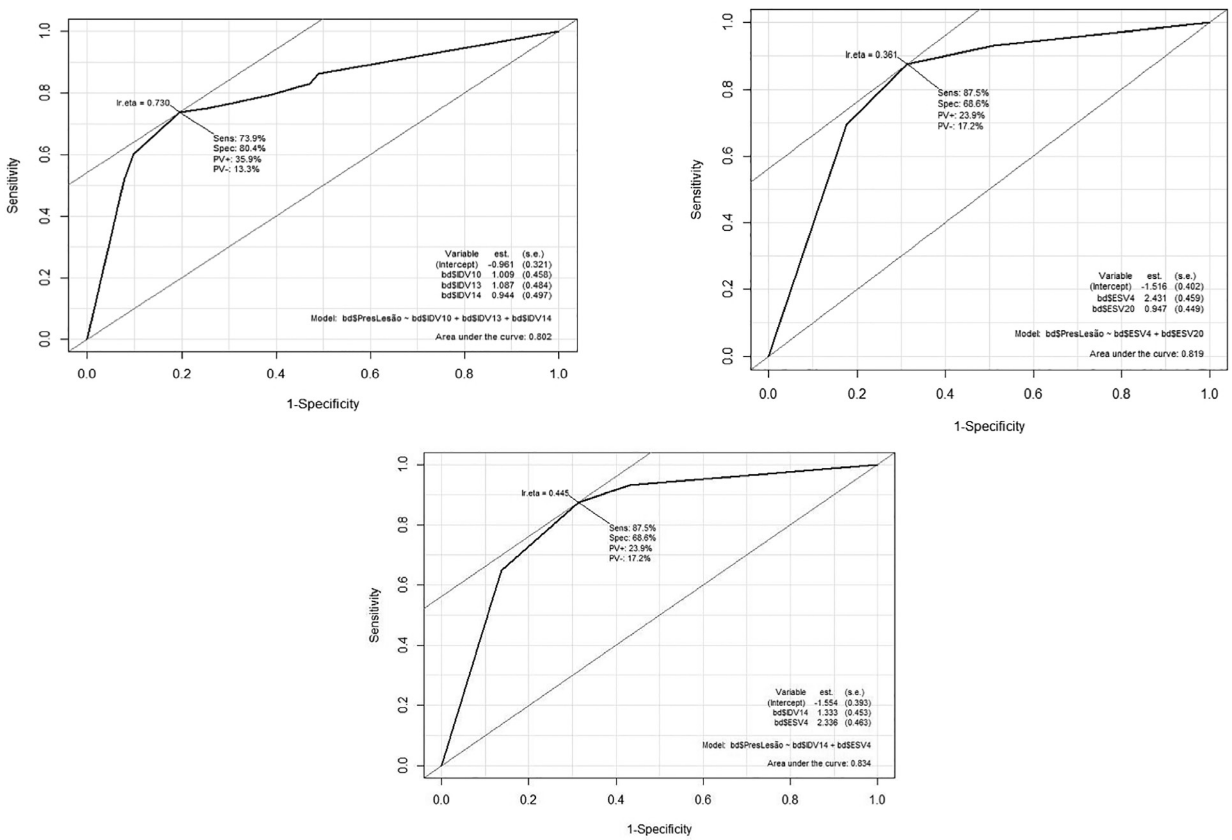

FIGURE 1. ROC curves of regressions of the IDV (*Índice de Desvantagem Vocal*), ESV (*Escala de Sintomas Vocais*) and Global models for the classification of the presence of dysphonia. **Source:** Search data.

presence of dysphonia. Although its success rate was the same as that of the IDV model, the Global model presented higher sensitivity and accuracy, making it the best option.

The probabilities were calculated for this model (Table 4). The cutoff point established by the ROC curve (CP = 0.687) guided decision making, and individuals with an estimated probability of above and below 68.7% should be classified as dysphonic and ND, respectively. According to the results, individuals answering "yes" to the two items of the model have an estimated probability of dysphonia of 89.2% and thus show signs of dysphonia. Similarly, any other type of response represents an estimated probability of dysphonia of less than the cutoff point (68.6%) and the absence of dysphonia.

The final version of the dysphonia screening instrument proposed here includes a simple decision-making flowchart based on the answers obtained for the two questions mentioned above to allow the examiner to determine the given case's best plan (Frame 1). We call this method Brazilian Dysphonia Screening Tool (Br-DST).

DISCUSSION

An instrument for screening dysphonia, called Br-DST, was proposed based on an analysis of the sensitivity, specificity, accuracy, and success obtained through the cross-validation of regression models adjusted to the available data. These models were interpreted from the estimated probabilities for

TABLE 3.
Analysis of the Mean Rate of Correct Answers in the Identify of Dysphonia Based on the Models Obtained Through a Cross-Validation Test

Model	S (%)	E (%)	A (%)	Hit rate	DP	IC
IDV Model	73.9	80.4	80.2	84.3%	12.86	[81.77; 86.81]
ESV Model	87.5	68.6	81.9	83.6%	10.96	[81.46; 85.76]
Global Model	87.5	68.6	83.4	84.3%	11.16	[81.99; 86.36]

Abbreviations: IDV, *Índice de Desvantagem Vocal*; ESV, *Escala de Sintomas Vocais*; S, Sensitivity; E, Specificity; A, Accuracy; SD, Standard deviation; IC, Confidence interval.

TABLE 4.
Possible Cases and Decision-Making Options for the Global Model

Situation	IDV 14	ESV 4	Estimated Probability (%)	Decision (PC = 68.7)
1	Yes	Yes	89.23	Yes
2	No	No	17.45	No
3	Yes	No	44.49	No
4	No	Yes	68.60	No

Abbreviations: IDV, *Índice de Desvantagem Vocal*; ESV, *Escala de Sintomas Vocais*; PC, cutoff point.

each possible response case and cutoff point established by the ROC curve.

The model using the QVV instrument items was excluded from the analysis due to its low predictive power and inability to adapt to the data. In the literature, a direct relationship between QVV or V-RQOL indexes and the presence of dysphonia is not unanimously accepted. While some studies find significant differences in the V-RQOL scores of those with and without voice disorders, others find no association between these disorders and impacts on quality of life measurable by the V-RQOL, questioning their discriminative capacity patients with dysphonia.[27–30] Also, it has been reported that the psychometric properties of the V-RQOL instrument were determined using a very small sample (n = 27), rendering its conclusions unreliable for use at the individual level and more suitable for use at the group level.[31]

The IDV model shows that three items belonging to the "organic" domain of the questionnaire are the most associated with the classification of dysphonia: "10. As pessoas perguntam: '*O que você tem na voz?*' (People ask me: 'What do you have in your voice?')"; "13. *Minha voz parece rouca e seca* (My voice seems hoarse and dry)" e "14. *Sinto que tenho que fazer força para a minha voz sair* (I feel like I have to force my speech)". Studies indicate that the organic domain includes the questions most frequently posed by individuals with voice complaints, which explains these items' selection by the model.[32, 33]

Item 10 refers to auditory impressions transmitted by the voice, indicating that the presented disorder manifests in a noticeable way to its interlocutors. Items 13 and 14 are symptoms identified by the patient and related to perceptions of hoarseness, dryness, and effort while speaking, manifestations that characterize a dysphonic condition and that may indicate the presence of laryngeal lesions.[8,34] Moreover, item 13 is the most significant, and individuals who perceive voice hoarseness and dryness are approximately three times more likely to be dysphonic. This result may be related to changes in the vocal fold's vibratory regularity related to voice hoarseness, a physiological process presents in most voice disorders. Besides, hoarseness is the voice symptom most widely recognized by the general population and the most frequently reported in the characterization of voice problems.[8]

The literature indicates that the accuracy for the total IDV score is 100.0%, characterizing this instrument as a perfect classifier in the identification of voice disorders.[4] In this study, the IDV model presented an accuracy level of 80.2%, denoting excellent classification. This result indicates that three items are responsible for much of this questionnaire's predictive capacity, which contains 30 items in its full version.

This accuracy could also characterize the IDV model developed here as a short and reliable tool to classify the dysphonia and select individuals with a high probability of being dysphonic in a population group. However, its specificity (80.4%) is higher than its sensitivity index (73.9%). Sensitivity is defined as the probability of a "sick" individual presenting a positive result for a given test. Simultaneously, specificity denotes a "normal" individual's probability of presenting a negative result for the question test. Therefore, the IDV model could be a more efficient tool for diagnostic confirmation than for initial screening, for which tests with high sensitivity are more appropriate.[25]

The most significant ESV model variables for dysphonia classification were "4. *Sua voz é rouca?* (Is your voice hoarse?)" and "20. *O som da sua voz muda durante o dia?*

FRAME 1.
Brazilian Dysphonia Screening Tool (Br-DST) Based on Items of Voice Self-Assessment Instruments

Question	Answer	Odds Ratio for Dysphonia (Yes)
1) *Sinto que tenho que fazer força para a minha voz sair* (I feel like I have to force my speech).	() Yes () No	2.6
2) *Minha voz é rouca* (My voice is hoarse)	() Yes () No	11.4
Decision Rule (Sensitivity = 87.5%, Specificity = 68.6% and Accuracy = 83.4%)		
A) Answer "yes" to both questions	Probability of dysphonia of 89.2%	Referral for detailed vocal evaluation
B) Answer "yes" only to question 2	Probability of dysphonia of 68.6%	Vocal guidance + patient monitoring
C) Other results	Probability of dysphonia of below 68.6%	Vocal guidance

(Does the sound of your voice change throughout the day?)", which both belong to the "limitation" domain. Item 4 corresponds to perceptions of hoarseness discussed above, and item 20 relates to the deterioration of the speaker's voice quality throughout the day. Deviated voices tend to vary more than healthy voices over short periods of time due to instability in laryngeal function, and the stability of voice quality also depends on the type of voice disorder, as different voice disorders involve different anatomical, physiological, or compensatory changes. However, voice disorders are widely considered to contribute to an increase in voice fluctuations.[35]

Patients with dysphonia tend to present higher levels of voice fatigue over the short and medium-term, that is, stronger perceptions of increased voice effort or tiredness, which probably implies a change in voice production patterns over time. Also, when acute laryngeal lesions are present, the loss of performance and more extended periods of voice fatigue and laryngeal discomfort are significantly more evident, as these symptoms reflect both neuromuscular fatigue and fatigue of the superficial layer of the lamina propria of the vocal folds.[36, 37]

The items of this model indicate that individuals answering "yes" to "Is your voice hoarse?" and "Does your voice change throughout the day?" are 11.4 and 2.6 more likely to be dysphonic, respectively, than those answering "no." For the IDV model, hoarseness perceptions have greater "weight" in the classification of the presence of dysphonia. From a physiological correlate of irregularity in vocal fold vibratory cycles, hoarseness is a highly valued symptom because it is present in most dysphonias, regardless of its nature or etiology, explaining its greater influence in identifying dysphonia according to the models presented here.

In terms of accuracy, similar to the IDV, the ESV is recognized by the literature as an optimal classifier for selecting dysphonic individuals.[4] The ESV model developed in this work has an accuracy index of 81.9%, demonstrating that only two items are responsible for a large proportion of the questionnaire's discriminative capacity, which has 30 items in total. With its higher sensitivity relative to the previous model and discrete superiority in accuracy, this model can be considered a better decision model than the IDV model for detecting dysphonia.

The Global model was developed to evaluate the performance of a dysphonia screening instrument proposed from the combination of the two most efficient questionnaires for the discrimination of this disorder, the IDV, and ESV, which is efficient but shorter, simpler, and easier to apply by any professional or speech therapist. The results were satisfactory; its sensitivity index is similar to that of the ESV model (87.5%), and it is more accurate than the other models investigated (83.4%), showing that this may be the most efficient model to correctly identify individuals about the presence of dysphonia.

IDV item 14 ("I feel I have to force my speech") and ESV item 4 ("Is your voice hoarse?") were the most relevant questions to ask to detect dysphonia. This result indicates that the sensory symptom of voice effort and auditory symptom of hoarseness is strongly associated with the disorder's presence, and an individual who responds yes to these two items has an estimated probability of being dysphonic of 89.23%.

Other researchers have highlighted the importance of individually analyzing each self-assessment questionnaire item examined in this work focused on this area.[6,15,16] In a study investigating the efficiency of items of the VHI in its reduced version of 10 items, it was observed that one item could not discriminate dysphonic patients from vocally healthy individuals, while another showed poor discrimination. The authors concluded that while the analysis of all instrument items is important in developing a broad understanding of the impact of dysphonia on a patient's life, the number of questions asked could be reduced to create a shorter but equally efficient version of this questionnaire for other purposes.[6]

Another study investigating the IDV via factor analysis suggested that the three-dimensional structure (emotional, functional, and physical) initially used by the instrument is psychometrically disabled, at least for Brazilian Portuguese, reflecting a severe limitation of this instrument. The analysis suggests that the instrument has a structure of two and not three factors and that even when a three-factor structure is imposed on the data, several items fail in its factorial load. Also, one-third of the items do not have clean factor loadings, and there also appears to be a correlation between the factors of the IDV-30, indicating redundancy in its structure.[15]

The analysis conducted here initially covered 70 items taken from three important self-assessment questions, which culminated in creating an instrument based on a decision model containing only two items to classify the presence of dysphonia.

The results of the cross-validation test, which assisted in the selection of the most efficient model by testing the performance of all models based on "new" data, together with the analysis of diagnostic indexes of sensitivity and accuracy, reveal that the Global model is the best for the identification of dysphonia. This model shows good sensitivity, accuracy, and efficiency in its classification of dysphonic and ND individuals. This result proves that during voice evaluation, certain information is more strongly associated with the clinical diagnosis of dysphonia and thus that this information can be used to detect this disorder through screening procedures.

Thus, the Global model was inserted into a decision-making instrument for dysphonia, the Br-DST, proposed here as a simple and efficient tool for screening this disorder based on probability estimates. Individuals who answer "yes" to the two questions included in this instrument have an estimated likely high of presenting the outcome "dysphonia" and, therefore, should be referred for detailed voice assessment and diagnostic confirmation. Individuals who answer "yes" only to the first question, "Is your voice hoarse?" should not be classified as dysphonic due to the estimated likely lower of presenting the outcome "dysphonia," but will require periodic follow-up of the condition, as this symptom has a high OR. Individuals who answer otherwise ("no" to the two questions or "yes" only to item "I feel I have to force my speech") should not be considered dysphonic due to the estimated probability low of presenting the outcome "dysphonia," and can receive personalized voice guidance but without a referral for complementary evaluations (Frame 1).

From there, it is possible to conclude that the Br-DST identifies potentially dysphonic individuals and supports an assertive decision-making within a preliminary voice assessment process, offering three different approaches to be adopted according to the answer presented by the individual to the two items investigated.

Notably, the instrument proposed here is not intended to be used as a diagnostic or evaluative tool for dysphonia or as a decision-making criterion for treatment. It is understood that voice disorders are complex and multidimensional processes and that their diagnosis requires a comprehensive analysis using several types of evaluations so that the integration of information from these evaluative procedures can lead to an appropriate diagnosis of the disorder presented. However, when one wishes to identify dysphonia in a group of numerous and heterogeneous individuals, given the few materials and human resources available, such as in population screenings, the use of a simple and efficient tool with a high-efficiency index can be quite beneficial.

CONCLUSION

It is possible to quickly screen for dysphonia using the Br-DST, a simple, high-efficiency instrument based on two easily understood items taken from two traditional voice self-assessment instruments. The protocol proposed here uses only the items "My voice is hoarse" and "I feel I have to force my speech," to track individuals with high probabilities of presenting dysphonia and refer them for in-depth evaluation. The proposed investigative tool can facilitate and simplify voice disorder screening.

It is important to highlight that the proposed instrument is valid exclusively for Brazilian Portuguese and that its use in other languages requires additional cultural adaptation since the declarations of the items contained therein may change according to the culture or language, and its predictive power may also vary according to the target population.

AUTHOR CONTRIBUTIONS

PO, EALN, LWL, MB, HMOL, and AAFA contributed to the construction and development of this work. POCS, EALN, and AAFA determined the objective and design of the study. POCS and HMOL led data collection and analysis and the writing of the manuscript; EALN contributed to the development of the study, to data analysis and final revisions of the manuscript; AAFA contributed to the development of the study, to the discussion of results, and the last revision of the manuscript; LWL and MB contributed to the discussion of the results and review of the manuscript for publication.

DECLARATION OF COMPETING INTEREST

The authors have no direct or indirect conflicts of interest to report for this work. All authors have approved the final version of the article.

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