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# The Perceived Stress Scale-10 as a screening tool for impaired atrial fibrillation-specific quality of life: Identification of an optimal cut-off value and incremental screening value

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**Research Article**

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## Abstract

# Background

To determine the optimal cutoff of the 10-item Perceived Stress Scale (PSS-10) for screening impaired atrial fibrillation (AF)-specific quality of life (QoL), and evaluate its incremental value beyond routine clinical variables.

# Methods

We performed a secondary analysis of a publicly available cross-sectional dataset of 196 community-dwelling adults with AF (Rush et al., PLoS One 2023). Impaired QoL was defined as an AFQoL-16 score at or below the 25th percentile (57.41 points). Associations were assessed by Spearman's correlation and multivariate logistic regression. ROC analysis identified the optimal cutoff. Incremental value over a base model (age, sex, time since last AF episode, self-rated overall health) was evaluated by DeLong test, net reclassification improvement (NRI), integrated discrimination improvement (IDI), and decision curve analysis (DCA).

# Results

Forty-nine patients (25.0%) had impaired QoL. PSS-10 was inversely correlated with AFQoL score ($rs=-0.385$, $P < 0.001$), with each 1-point increase conferring 11.3% higher odds of impaired QoL. The AUC was 0.701 (95%CI 0.617–0.784); the optimal cutoff was ≥ 16 points (sensitivity 57.1%, specificity 78.2%). Adding PSS-10 to the base model increased AUC from 0.769 to 0.827 (NRI 0.490, $P = 0.005$; IDI 0.062, $P = 0.006$), with DCA confirming greater net benefit across clinically relevant thresholds.

# Conclusions

PSS-10 is independently associated with AF-specific QoL impairment. A cutoff of 16 points offers acceptable screening performance and significant incremental value beyond routine variables, supporting its use as a simple first-line screening tool, though external validation in independent cohorts is needed.

## Background

Atrial fibrillation (AF) is the most common form of sustained cardiac arrhythmia worldwide. A systematic analysis of the Global Burden of Disease Study 2021 revealed that more than 52 million individuals were living with AF or atrial flutter in 2021, with projections estimating a substantial further increase in burden by 2046 [1]. Global trend analyses covering 1990–2019 likewise indicate rising prevalence, incidence, and mortality, together with a heavy load of modifiable risk factors [2–4]. Symptom episodes, stroke risk,

and the demand for long-term anticoagulation can all substantially impair health-related quality of life (QoL). Improving QoL has accordingly arisen as a core objective of AF management alongside the reduction of mortality and cardiovascular events. Both the 2024 ESC Guidelines for the management of AF and the 2023 ACC/AHA/ACCP/HRS guidelines advocate a patient-centered integrated care pathway and explicitly recommend performing routine assessment of symptom burden and psychosocial factors [5, 6].

The Atrial Fibrillation Quality of Life questionnaire (AFQoL-16) is a disease-specific instrument covering symptom, daily-activity and treatment-concern domains, with a well-documented reliability and validity [7]. However, systematic reviews show that the measurement properties of existing AF-specific QoL instruments are heterogeneous [8], while multi-item questionnaires remain relatively time-consuming and cumbersome to score; the development of new instruments likewise stresses patient perspectives, clinical feasibility and patient engagement [9, 10]. These characteristics can all hamper their routine use in busy outpatient clinics and large-scale settings. Therefore, a simple, feasible, and valid screening tool that rapidly identifies patients at high risk of QoL impairment would have considerable clinical and public health relevance.

Perceived stress—defined as the degree to which individuals appraise situations in their lives as unpredictable, uncontrollable, and overloaded—is closely associated with the onset and prognosis of cardiovascular disease. The Perceived Stress Scale (PSS), developed by Cohen et al. [11], is the most widely used measure of this construct, the reliability and validity of which have been confirmed in systematic evaluations across different languages and populations [12], including Chinese-speaking cardiac patients [13]. The psychometric properties of the PSS-10 have also been validated [14], and it is an independent predictor of symptom severity and QoL [15]. One prior meta-analysis of cohort studies indicated that adverse psychological factors—including anxiety, depression, and work stress—are associated with 10%, 25%, and 18% higher risks of incident AF, respectively [16]; these factors are also highly prevalent among patients with established AF and may affect patient-reported outcomes [17]. Cross-sectional evidence further indicates that patients with AF who report higher psychological stress have a worse QoL [18]. However, whether PSS-10 can quantitatively identify impaired AF-specific QoL, the optimal cut-off value and whether it adds incremental value beyond routinely available clinical variables remain unknown.

To address these gaps, we conducted a secondary analysis of a publicly available cross-sectional dataset of community-dwelling adults with AF, published by Rush et al. The aims were to: (i) quantify the association between PSS-10 scores and AF-specific QoL; (ii) determine the optimal cut-off value and diagnostic performance of the PSS-10 to identify impaired AF-specific QoL; and (iii) evaluate its incremental screening value beyond routine clinical variables, thereby providing a potential simple two-step triage screening strategy.

# Methods

## 2.1 Data source and study population

Data were derived from a cross-sectional study by Rush et al., published in PLoS One in 2023 [18], which investigated the multidimensional determinants of QoL among community-dwelling adults with AF within a theory-driven framework. All deidentified raw data are publicly available from the Dryad Digital Repository. The analytical dataset comprised 196 patients with complete medical records. Inclusion criteria were: age ≥ 18 years, clinically confirmed AF, and completion of both the AFQoL-16 and the PSS-10. This study involved a secondary analysis of fully de-identified publicly available data. The original study obtained ethical approval and informed consent from the participants; therefore, additional ethical review was not required for the present secondary analysis, which followed the STROBE statement and the recommendations of the TRIPOD statement for clinical prediction models [19].

## 2.2 Variable definitions

Exposure: Perceived stress was measured using the PSS-10 (10 items scored on a scale of 0–4; total range 0–40, with higher scores indicating greater perceived stress) [11, 15]; the observed range in this dataset was 0–31.

Outcome: Impaired atrial fibrillation-specific quality of life (QoL) was assessed using the standardized AFQoL-16 total score (scored on a scale from 0–100, with higher scores indicating better QoL) [7]. Because no consensus clinical threshold exists for the AFQoL-16 questionnaire, patients whose total score fell at or below the lowest quartile of the study sample (25th percentile = 57.41 points) were empirically classified as having impaired QoL; a median split (≤ 74.07 points) functioned only as an alternative definition for sensitivity analyses and was not intended as a clinical outcome threshold.

Covariates: Age, sex (coded 1 = male), time since the last AF episode (grades 1–6), self-rated mental health (grades 1–6), self-rated overall health (grades 1–5), AF treatment satisfaction (AFEQT score, 0–100), AF knowledge score (0–100), household activity limitation score, and recreational activity limitation score were all analyzed as covariates.

## 2.3 Statistical analysis

All statistical analyses were conducted using the FengRui statistical software (version 1.0, FengRui Technology, Shenzhen, China). Continuous variables were examined for normality using the Shapiro-Wilk test; as all key variables were skewed, they are presented as medians with interquartile ranges (M [P25, P75]) and differences were compared between groups using the Mann-Whitney U test. Categorical variables are expressed as the n (%) and were compared using the $\chi^2$ test. Associations between the PSS-10 and QoL indicators were assessed using Spearman's rank correlation.

Univariable logistic regression (entry criterion $\alpha = 0.10$) was followed by a multivariable model built using backwards elimination (removal criterion $\alpha = 0.05$), with age and sex forced into the model; results are presented as odds ratios (ORs) with 95% confidence intervals (CIs).

The diagnostic performance was evaluated using receiver operating characteristic (ROC) curves. Areas under the curve (AUCs) are reported with 95% CIs estimated using the DeLong method [20]; the optimal cut-off maximized the Youden index (sensitivity + specificity − 1); sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), likelihood ratios, and accuracy are reported.

The incremental value was assessed through comparison with a base model containing only routinely available variables (age, sex, time since the last AF episode, and self-rated overall health). AFEQT treatment satisfaction was excluded from the base model because of a conceptual overlap with the AFQoL-16 outcome, both of which evaluated AF-related symptom burden and treatment-related concerns. The inclusion of the AFEQT would likely overestimate the incremental predictive value of the PSS-10. The combined model included the PSS-10 total score. The difference in AUC (ΔAUC) was tested using the paired DeLong method [21]; categorical net reclassification improvement (NRI, with impaired/non-impaired as event/non-event definitions) and integrated discrimination improvement (IDI) were also calculated [22], with CIs and P values derived from 2000 bootstrap resamples; decision curve analysis (DCA) quantified the clinical net benefit across threshold probabilities [23]. Internal validation was conducted using a bootstrap optimism correction procedure (500 resamples). Variable selection by backward elimination is an exploratory strategy, the results of which should be verified using forced entry models in subsequent studies. All tests were two-sided, and statistical significance was set at $P < 0.05$.

## Results

# 3.1 Baseline characteristics

A total of 196 patients were analyzed (age median 66.50 [60.00–71.00] years; 73 [37.2%] men), of whom 49 (25.0%) had impaired AF-specific QoL. The two groups did not differ significantly in terms of age, sex distribution, AF knowledge score, or activity limitation scores (all $P > 0.05$). Compared with the non-impaired group, the impaired group had markedly higher PSS-10 scores [16.00 (12.00–20.00) vs 11.00 (7.00–15.00), $Z = 4.201$, $P < 0.001$], lower grades of time since the last AF episode ($Z = -4.714$, $P < 0.001$), poorer self-rated overall and mental health (both $P < 0.05$), and lower treatment satisfaction ($P < 0.001$) (Table 1).

Table 1

**Baseline characteristics of patients with and without impaired atrial fibrillation-specific quality of life**

*Values are presented as n (%) or median [P25, P75]. PSS-10: 10-item Perceived Stress Scale; AFQoL: Atrial Fibrillation Quality of Life questionnaire; BMI: body mass index; CHA2DS2-VASc: congestive heart failure, hypertension, age ≥ 75 years, diabetes mellitus, stroke, vascular disease, age 65–74 years, sex category; HAS-BLED: hypertension, abnormal renal/liver function, stroke, bleeding, labile INR, elderly, drugs/alcohol.*

| Characteristic | Overall (n = 196) | Non-impaired (n = 147) | Impaired (n = 49) | Z/χ² | P value |
|---|---|---|---|---|---|
| Age, years | 66.5 (60–71) | 67 (59–71) | 66 (62–72) | 0.486 | 0.628 |
| Male sex | 73 (37.2) | 54 (36.7) | 19 (38.8) | 0.065 | 0.798 |
| Time since last AF episode, grade (1–6) | 3 (1–4) | 4 (2–4) | 2 (1–3) | 4.714 | < 0.001 |
| Self-rated mental health, grade (1–6) | 3 (3–4) | 3 (3–4) | 3 (3–4) | 1.980 | 0.028 |
| Self-rated overall health, grade (1–5) | 3 (2–3) | 3 (3–3) | 2 (2–3) | 3.722 | < 0.001 |
| Perceived stress (PSS-10), points | 12.47 ± 6.41 | 11.00 (7.00–15.00) | 16.00 (12.00–20.00) | 4.201 | < 0.001 |
| AFEQT treatment satisfaction, points | 73.85 ± 26.13 | 83.33 (66.67–100.00) | 66.67 (33.33–83.33) | 4.868 | < 0.001 |
| AF knowledge score, points | 83.03 ± 11.99 | 83.33 (79.17–91.67) | 87.50 (79.17–91.67) | 0.708 | 0.475 |
| Household activity limitation score | 31.54 ± 12.54 | 31.00 (25.00–37.00) | 31.00 (20.00–42.00) | 0.573 | 0.567 |
| Recreational activity limitation score | 37.03 ± 20.99 | 33.29 (21.83–48.88) | 31.00 (20.00–52.92) | 0.294 | 0.770 |
| AFQoL total score | 70.62 ± 21.45 | 82.41 (70.37–91.67) | 42.59 (34.31–48.15) | 10.473 | < 0.001 |
| AFQoL symptom domain | 75.23 ± 21.39 | 83.33 (75.00–95.83) | 50.00 (41.67–70.83) | 7.735 | < 0.001 |
| AFQoL daily activities domain | 69.93 ± 27.21 | 85.42 (69.79–97.92) | 35.42 (22.92–45.83) | 9.953 | < 0.001 |
| AFQoL treatment concern domain | 68.47 ± 22.24 | 80.56 (69.44–88.89) | 38.89 (25.00–52.78) | 9.108 | < 0.001 |

Table 1. **Baseline characteristics of patients with and without impaired AF-specific quality of life**

For the overall column, age and ordinal ratings are shown as M [P25, P75]; PSS-10, treatment satisfaction, knowledge, activity limitation scores and AFQoL domain scores are shown as mean ± SD. For group comparisons, continuous variables are shown as M [P25, P75] and compared using the Mann-

Whitney U test; male sex is shown as n (%) and compared with the $\chi^2$ test. Impaired QoL was defined as an AFQoL total score at or below the sample's 25th percentile (≤ 57.41 points).

## 3.2 Correlation between PSS-10 and AF-specific QoL

Spearman correlation analysis revealed inverse correlations between PSS-10 scores and the total AFQoL score (rs=-0.385, P < 0.001; Fig. 1), as well as with the symptom domain (rs=-0.312), daily activities domain (rs=-0.311), and treatment concern domain (rs=-0.401; all P < 0.001). A weak inverse correlation was found with treatment satisfaction (rs=-0.221, P = 0.002), while no significant correlations were found with AF knowledge, household, or recreational activity scores (all P > 0.05) (Table 2).

Table 2
**Spearman correlations between PSS-10 scores and atrial fibrillation-specific quality of life** *PSS-10: 10-item Perceived Stress Scale; AFQoL: Atrial Fibrillation Quality of Life questionnaire.*

| Indicator | rs | P value |
|---|---|---|
| AFQoL total score | -0.385 | < 0.001 |
| AFQoL symptom domain | -0.312 | < 0.001 |
| AFQoL daily activities domain | -0.311 | < 0.001 |
| AFQoL treatment concern domain | -0.401 | < 0.001 |
| AFEQT treatment satisfaction | -0.221 | 0.002 |
| AF knowledge score | -0.020 | 0.783 |
| Household activity limitation score | 0.022 | 0.764 |
| Recreational activity limitation score | -0.103 | 0.149 |

Table 2. **Spearman correlations between PSS-10 scores and AF-specific QoL and related indicators**

Figure 1. **Scatter plot of PSS-10 scores against AFQoL total scores in patients with atrial fibrillation (n = 196)**

The distribution of PSS-10 scores shifted upward in the impaired group (median 16.00 [12.00–20.00] vs 11.00 [7.00–15.00] points; Mann-Whitney U Z = 4.201, P < 0.001; effect size r = 0.300), as shown in Fig. 2.

Figure 2. **Distribution of PSS-10 scores in the non-impaired and impaired QoL groups**

## 3.3 Factors associated with impaired QoL

In the univariate logistic regression, time since the last AF episode, self-rated mental health, self-rated overall health, treatment satisfaction, and PSS-10 score were all found to be associated with impaired QoL, while age, sex, AF knowledge, and activity limitation scores showed no significant associations. In the multivariable backward-elimination model (age and sex forced in), each 1-point increase in PSS-10

conferred an 11.3% higher risk of impaired QoL (OR = 1.113, 95%CI 1.042–1.189, P = 0.001). Conversely, each higher grade of time since the last AF episode reduced the risk by 35.2% (OR = 0.648, P = 0.003); each higher grade of self-rated overall health reduced the risk by 43.7% (OR = 0.563, P = 0.050); and each 10-point increase in treatment satisfaction reduced the risk by 17.7% (OR = 0.823, P = 0.012) (Table 3).

Table 3

**Univariable and multivariable logistic regression analyses of factors associated with impaired atrial fibrillation-specific quality of life** *OR: odds ratio; CI: confidence interval; PSS-10: 10-item Perceived Stress Scale; BMI: body mass index.*

| Variable | Univariable OR (95%CI) | P value | Multivariable OR (95%CI) | P value |
|---|---|---|---|---|
| Age (per 1-year increase) | 1.009 (0.977–1.041) | 0.603 | 1.034 (0.994–1.075) | 0.096 |
| Male sex | 1.091 (0.561–2.122) | 0.798 | 0.772 (0.340–1.753) | 0.537 |
| Time since last AF episode (per grade higher) | 0.550 (0.423–0.715) | < 0.001 | 0.648 (0.487–0.864) | 0.003 |
| Self-rated mental health (per grade higher) | 0.563 (0.346–0.917) | 0.021 | — | — |
| Self-rated overall health (per grade higher) | 0.338 (0.200–0.571) | < 0.001 | 0.563 (0.316–1.000) | 0.050 |
| Treatment satisfaction (per 10 points) | 0.739 (0.651–0.840) | < 0.001 | 0.823 (0.707–0.958) | 0.012 |
| AF knowledge score (per 10 points) | 1.072 (0.811–1.417) | 0.625 | — | — |
| Household activity limitation (per 10 points) | 0.932 (0.719–1.207) | 0.592 | — | — |
| Recreational activity limitation (per 10 points) | 1.005 (0.861–1.172) | 0.953 | — | — |
| Perceived stress PSS-10 (per 1-point increase) | 1.127 (1.065–1.193) | < 0.001 | 1.113 (1.042–1.189) | 0.001 |

Table 3. **Univariable and multivariable logistic regression analyses of factors associated with impaired AF-specific quality of life**

OR, odds ratio; CI, confidence interval. The multivariable model was built by backward elimination (removal α = 0.05) with age and sex forced into the model. Treatment satisfaction, knowledge and household/recreational activity limitation scores were analysed per 10-point increment, other variables per 1-unit increment. '—' indicates that the variable was not retained in the corresponding model.

# 3.4 Diagnostic performance and optimal cut-off value of the PSS-10

In ROC analysis, PSS-10 yielded an AUC of 0.701 (95%CI 0.617–0.784) for identifying impaired AF-specific QoL, clearly exceeding that of age alone (AUC = 0.523, 95%CI 0.432–0.614) and reverse-scored self-rated overall health (AUC = 0.678, 95%CI 0.597–0.759) (note: these are exploratory descriptive comparisons, not subject to formal statistical testing). At the Youden-optimal cut-off of ≥ 16 points, sensitivity was 57.1% and specificity 78.2% (Youden index 0.354); PPV was 46.7%, NPV 84.6%, accuracy 73.0%, LR + 2.62 and LR − 0.55. The results are summarized in Table 4 and Fig. 3.

Table 4

**Diagnostic performance of PSS-10 and other indicators for screening impaired atrial fibrillation-specific quality of life** *AUC: area under the curve; CI: confidence interval; PSS-10: 10-item Perceived Stress Scale; PPV: positive predictive value; NPV: negative predictive value.*

| Indicator | AUC (95%CI) | Optimal cut-off | Sensitivity (%) | Specificity (%) | Youden index | PPV (%) | NPV (%) |
|---|---|---|---|---|---|---|---|
| PSS-10 total score (points) | 0.701 (0.617–0.784) | ≥ 16 | 57.1 | 78.2 | 0.354 | 46.7 | 84.6 |
| Age (years) | 0.523 (0.432–0.614) | — | — | — | — | — | — |
| Self-rated overall health (reverse-scored) | 0.678 (0.597–0.759) | ≤ 2 (reversed) | 51.0 | 81.0 | 0.320 | 47.2 | 83.2 |
| Base model | 0.769 (0.699–0.840) | 0.173 | 89.8 | 54.4 | 0.442 | 39.6 | 94.1 |
| Base model + PSS-10 | 0.827 (0.768–0.886) | 0.169 | 93.9 | 63.3 | 0.571 | 46.0 | 96.9 |

Table 4. **Diagnostic performance of PSS-10 and other indicators for screening impaired AF-specific quality of life**

AUC, area under the ROC curve; PPV/NPV, positive/negative predictive value. The optimal cut-off maximized the Youden index; a positive screen was defined as a PSS-10 score ≥ 16 or self-rated overall health ≤grade 2 (reverse-scored ≥ 2). For the two logistic models, the cut-off is the predicted probability at the Youden optimum. Base model: age, sex, time since last AF episode grade, self-rated overall health; combined model: base model + PSS-10 total score.

Figure 3. **Receiver operating characteristic curve of PSS-10 for screening impaired AF-specific quality of life**

# 3.5 Incremental screening value of PSS-10

Including PSS-10 increased the AUC from 0.769 (95%CI 0.699–0.840) in the base model to 0.827 (95%CI 0.768–0.886) in the combined model (ΔAUC = 0.058; DeLong Z = 4.968, P < 0.001; Fig. 4A). The NRI was 0.490 (95%CI, 0.132–0.868; P = 0.005), with predicted risks reclassified upward in 61.2% of events and downward in 63.3% of non-events, with an IDI of 0.062 (95%CI 0.005–0.159, P = 0.006) (Table 5). Decision curve analysis revealed a consistently higher net benefit for the combined model across threshold probabilities of approximately 2–62% (Fig. 4B). Bootstrap internal validation (500 re-samples) yielded an optimism of only 0.023 and an optimism-corrected AUC of 0.803, indicating good internal stability. At the optimal cut-off of the combined model, the sensitivity was 93.9%, specificity was 63.3%, PPV was 46.0%, and NPV was 96.9%.

Table 5
**Incremental screening value of adding PSS-10 to the base model of routine clinical variables** *AUC: area under the curve; CI: confidence interval; NRI: net reclassification improvement; IDI: integrated discrimination improvement; PSS-10: 10-item Perceived Stress Scale.*

| Metric | Point estimate | 95%CI | Test statistic | P value |
|---|---|---|---|---|
| ΔAUC (combined − base) | 0.058 | — | Z = 4.968 | < 0.001 |
| NRI | 0.490 | 0.132–0.868 | — | 0.005 |
| IDI | 0.062 | 0.005–0.159 | — | 0.006 |

Table 5. **Incremental screening value of adding PSS-10 to the base model**

ΔAUC, difference in AUC between the combined and base models, tested with the paired DeLong method. NRI/IDI CIs and P values were derived from 2000 bootstrap resamples. Base model: age + sex + time since last AF episode grade + self-rated overall health; combined model: base model + PSS-10 total score.

Figure 4. **Incremental screening value of PSS-10: (A) comparison of ROC curves between the base and combined models; (B) decision curve analysis**

## 3.6 Sensitivity analyses

When the outcome was re-defined by the median split (AFQoL total score ≤ 74.07 points, n = 100 impaired), the findings were directionally identical: the AUC of PSS-10 was 0.689 with the same optimal cut-off of ≥ 16 points (sensitivity 45.0%, specificity 84.4%), while the combined model (AUC = 0.818) still outperformed the base model (AUC = 0.780) with ΔAUC = 0.037, P < 0.001, supporting the robustness of the main findings.

# Discussion

Overall, three principal findings emerged from this secondary analysis of a publicly available cross-sectional dataset of community-dwelling adults with AF. First, PSS-10 scores were found to be inversely

correlated with the AFQoL total score and individually with all three of its domains (rs = − 0.311 to − 0.401). Second, PSS-10 provided a fair screening value for impaired AF-specific QoL (AUC = 0.701), with a candidate cut-off of ≥ 16 points at which both the specificity (78.2%) and NPV (84.6%) were high. Third, adding PSS-10 to routine clinical variables significantly improved discrimination (ΔAUC = 0.058), reclassification (NRI = 0.490), and overall resolution (IDI = 0.062), with decision curves confirming a higher clinical net benefit across a wide range of thresholds. Taken together, these results support the PSS-10 as a simple first-line screening instrument for QoL impairment in patients with AF.

The study findings agree with and extend previous evidence. In the original study by Rush et al., perceived stress was among the most important psychosocial correlates of QoL in patients with AF [18], while both the 2024 ESC Guidelines and the 2023 ACC/AHA/ACCP/HRS Guidelines recommended incorporating psychological assessment into integrated AF care [5, 6]. We now provide an operational quantitative standard: the candidate cut-off of 16 points (the statistically optimal value maximizing the Youden index) lies slightly above the lower limit of the conventional 'moderate stress' band (14 points) [11], indicating that patients reporting moderate or greater perceived stress warrant closer attention to their QoL and timely confirmatory assessment with disease-specific instruments, such as the AFQoL-16. The bidirectional association between psychological distress and AF outcomes has previously been confirmed by a meta-analysis of cohort studies [16]. Plausible mechanisms include sympathetic activation, hypothalamic-pituitary-adrenal dysregulation, pro-inflammatory states, sleep disturbance, and adverse health behaviors (reduced physical activity and poor treatment adherence), which could aggravate symptom burden and thereby impair QoL. Conversely, QoL impairment may amplify stress appraisal, thereby creating a vicious circle that makes early identification particularly important.

Our results echo recent global evidence from around the world. In older adults with AF, anxiety and depressive symptoms, as well as frailty, are all associated with poorer QoL [23]. For example, one Chinese cross-sectional study revealed that coping strategy and psychological status partially mediate the relationship between illness perception and QoL [24]; nurse-led multi-component behavioral activation improves health outcomes in patients with AF [25], and holistic management of older multimorbid patients further supports the feasibility of stratified care pathways built on screening results [26]. In interventional settings, depressive and anxiety symptoms have been shown to impair QoL after cryoballoon ablation [27], are highly prevalent among patients undergoing catheter ablation for AF [28], and predict higher recurrence after ablation [29]. Symptom-cluster research has also shown that distinct symptom clusters independently shape the QoL burden of different ablation candidates [30]. Sex-specific differences in symptom burden and outcomes after ablation have also been reported [31], indicating that confirmatory evaluation after a positive screening should consider sex-related factors.

From a screening strategy perspective, the combined model showed high sensitivity with a high NPV (96.9%); thus, patients with low PSS-10 scores could be rapidly ruled out, while a positive screen (PPV 46.0%) should trigger a confirmatory evaluation with the AFQoL-16, an arrangement consistent with the intended role of a first-line triage tool. Notably, the PSS-10 takes only a few minutes to complete and requires no equipment or laboratory tests, giving it a near-zero marginal cost compared to biomarker-

based approaches, making it attractive for outpatient clinics, primary care, and large cohort follow-ups [11].

This study had several limitations. First, the cross-sectional design precludes any causal inference, while a reciprocal influence between perceived stress and QoL cannot be excluded. Second, in the absence of a consensus clinical threshold for the AFQoL-16, we used a relative, sample-based definition (lowest quartile). The original validation study of the AFQoL-16 did not establish a clinically meaningful cutoff [7], and subsequent work has not filled this gap; although the more widely used AFEQT instrument has adopted thresholds such as a score below 80 to denote impaired QoL in some cohorts, these cutoffs are not directly transferable to the AFQoL-16 owing to differences in item content and scoring. Consequently, the reported prevalence of impaired QoL (25.0%) and the associated screening metrics are inherently sample-dependent and may not generalize to populations with different QoL distributions. Although sensitivity analyses using the median split were concordant, the absolute cutoff requires external validation in prospective cohorts and different populations, and future studies should establish a clinically validated threshold for the AFQoL-16—ideally anchored to patient-reported symptom severity or functional impairment—before the PSS-10 cutoff can be adopted in clinical practice. Third, the data originated from a Canadian community sample, and some variables were imputed by the original investigators; therefore, generalization, particularly to Chinese populations, warrants caution [32]. Fourth, both the PSS-10 and AFQoL are self-reported instruments, and common method bias cannot be ruled out. Fifth, psychiatric diagnoses (anxiety and depression), left ventricular ejection fraction, and comorbidity burden were all unavailable. Therefore, the incremental value was evaluated only against routine questionnaire-level variables. Sixth, the sample size (196 patients, 49 events) yielded an events-per-variable ratio (EPV) of 9.8, slightly below the recommended threshold of 10, which may increase the risk of overfitting, although the bootstrap optimism was only 0.023. Seventh, backward elimination was used for variable selection, an exploratory strategy susceptible to selection bias. Forced-entry models are recommended for future studies. Eighth, no calibration assessment (e.g., Hosmer-Lemeshow test or calibration curve) was conducted; the calibration of the combined model therefore warrants further evaluation. Ninth, NRI was defined categorically (impaired/non-impaired), which may have discarded the information carried by the continuous predictor.

Nevertheless, our results showed that PSS-10 is independently associated with AF-specific quality of life, and a candidate cut-off of ≥ 16 points provides acceptable screening performance and adds significant incremental value beyond routine clinical variables. This candidate cutoff value awaits external validation in prospective multi-population studies.

# Conclusions

Overall, the present study found that PSS-10 is independently associated with AF-specific quality of life; a candidate cut-off of ≥ 16 points provides acceptable screening performance (sensitivity 57.1%, specificity 78.2%). Adding PSS-10 to routinely collected clinical variables yields incremental screening

value (ΔAUC = 0.058). This candidate cutoff value requires external validation in prospective multi-population studies.

# Abbreviations

AF
atrial fibrillation
PSS-10
10-item Perceived Stress Scale
QoL
quality of life
AFQoL-16
Atrial Fibrillation Quality of Life questionnaire (16-item)
ROC
receiver operating characteristic
AUC
area under the curve
NRI
net reclassification improvement
IDI
integrated discrimination improvement
DCA
decision curve analysis
OR
odds ratio
CI
confidence interval
PPV
positive predictive value
NPV
negative predictive value
AFEQT
Atrial Fibrillation Effect on QualiTy of Life.

# Declarations

**Ethics approval and consent to participate**

This study is a secondary analysis of de-identified data publicly released by the Dryad Digital Repository. Ethical approval and informed consent for the original study were obtained and disclosed by the original

investigators (Rush et al., PLoS One, 2023). Additional ethical review was not required for the present secondary analysis.

### Consent for publication

Not applicable. This study uses de-identified publicly available data; no individual patient data or images are presented.

### Competing interests

The authors declare that they have no competing interests.


### Funding

None.


### Authors' contributions

HY conceived the study, performed the statistical analysis, and drafted the manuscript. XL contributed to data interpretation and critical revision of the manuscript. JH supervised the study, interpreted the data, and critically revised the manuscript. All authors read and approved the final manuscript.


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### Availability of data and materials

The dataset analysed in this study is openly available in the Dryad Digital Repository (Rush et al., PLoS One, 2023; https://doi.org/10.5061/dryad...).

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# Figures

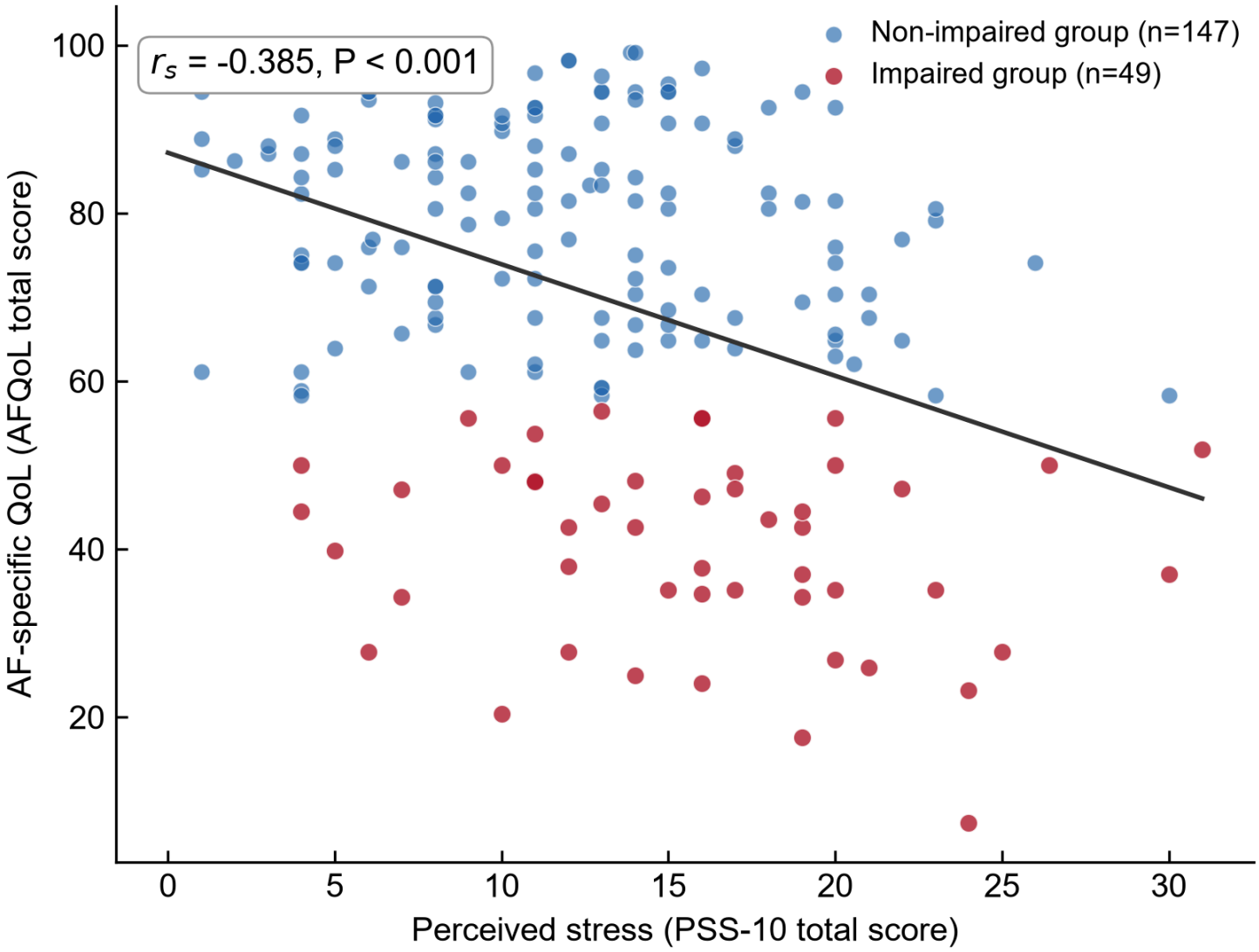



**Figure 1**

Scatter plot of PSS-10 scores against AFQoL total scores in patients with atrial fibrillation (n = 196).

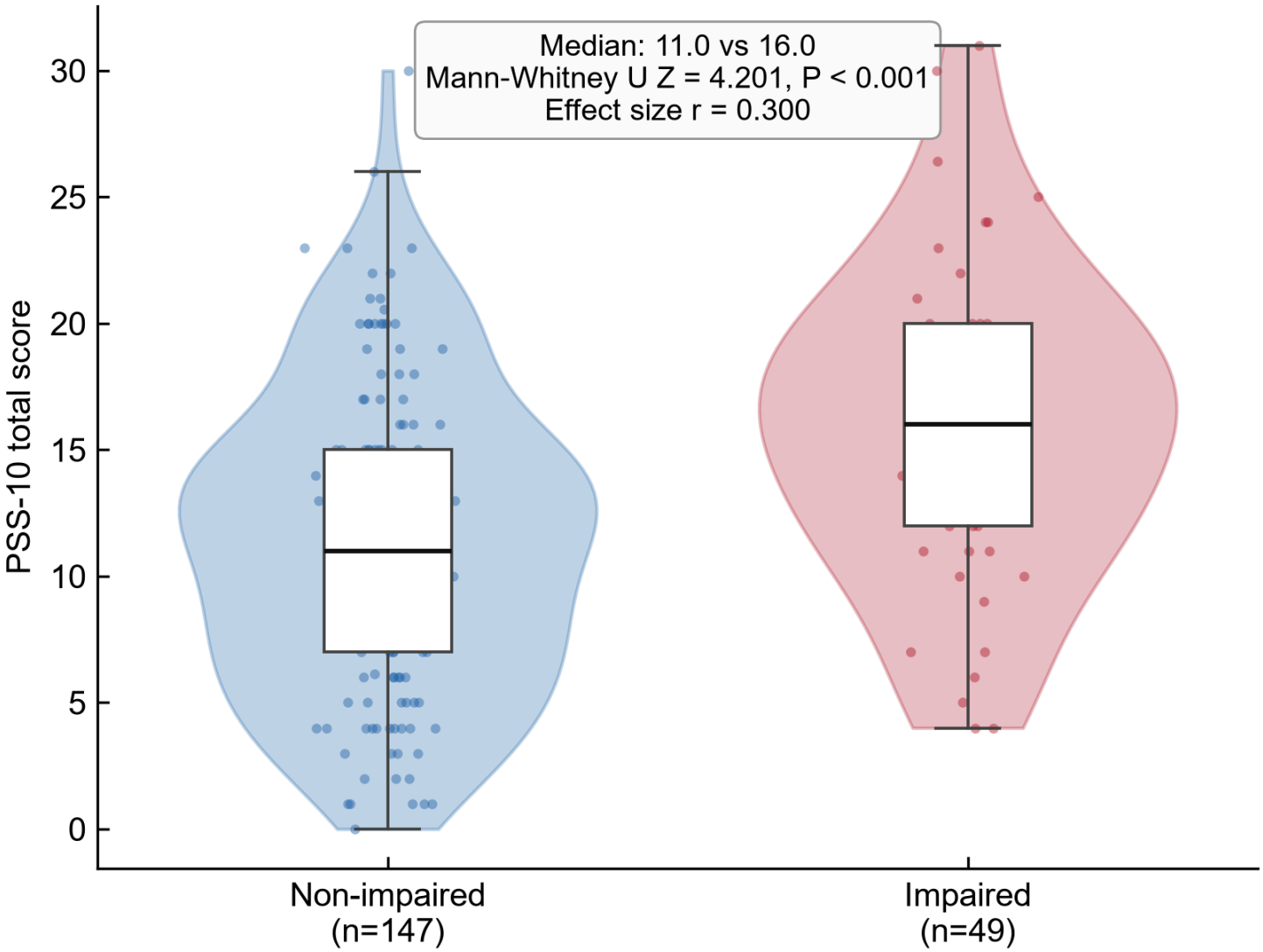



**Figure 2**

Distribution of PSS-10 scores in the non-impaired and impaired QoL groups.

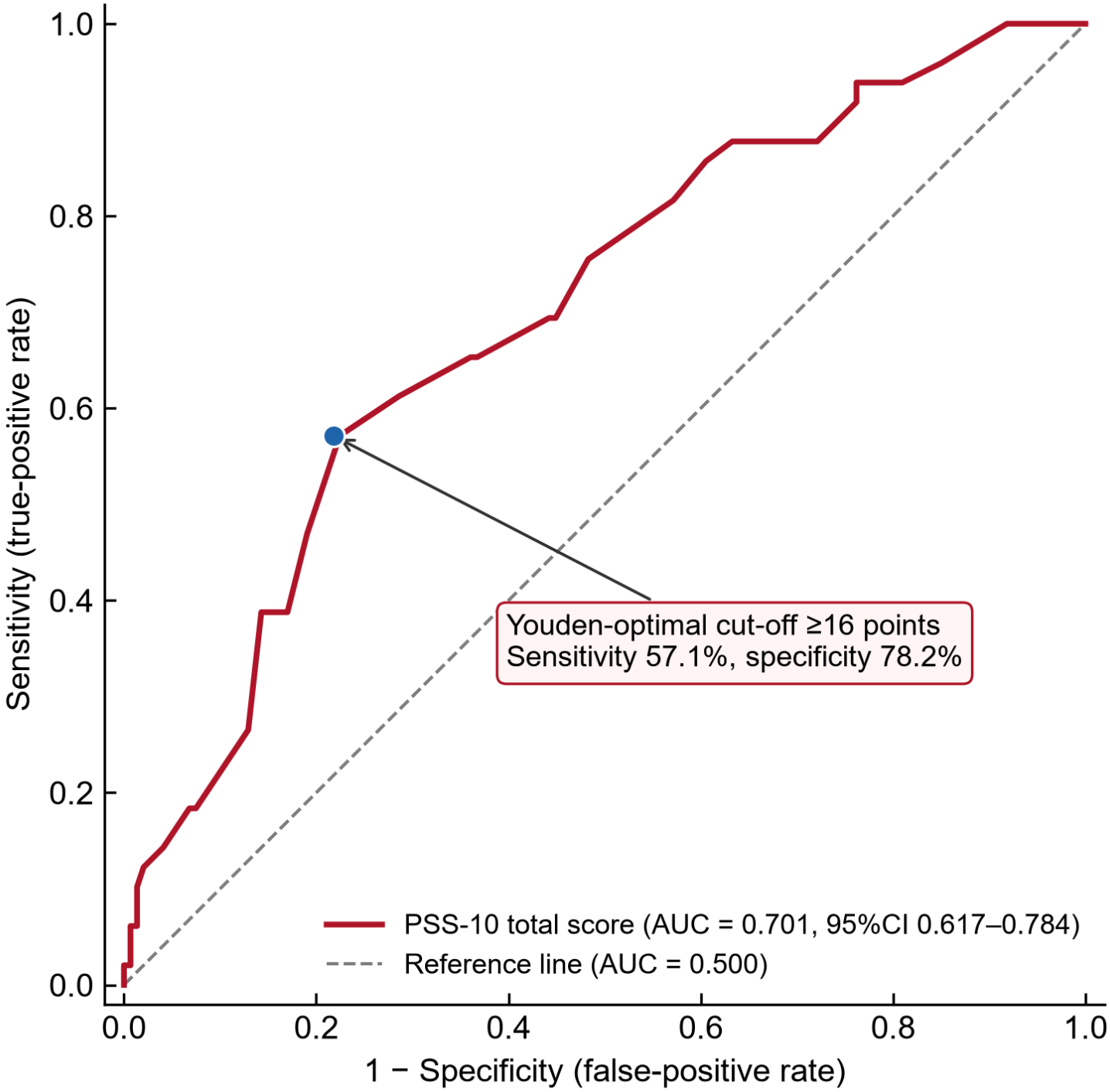
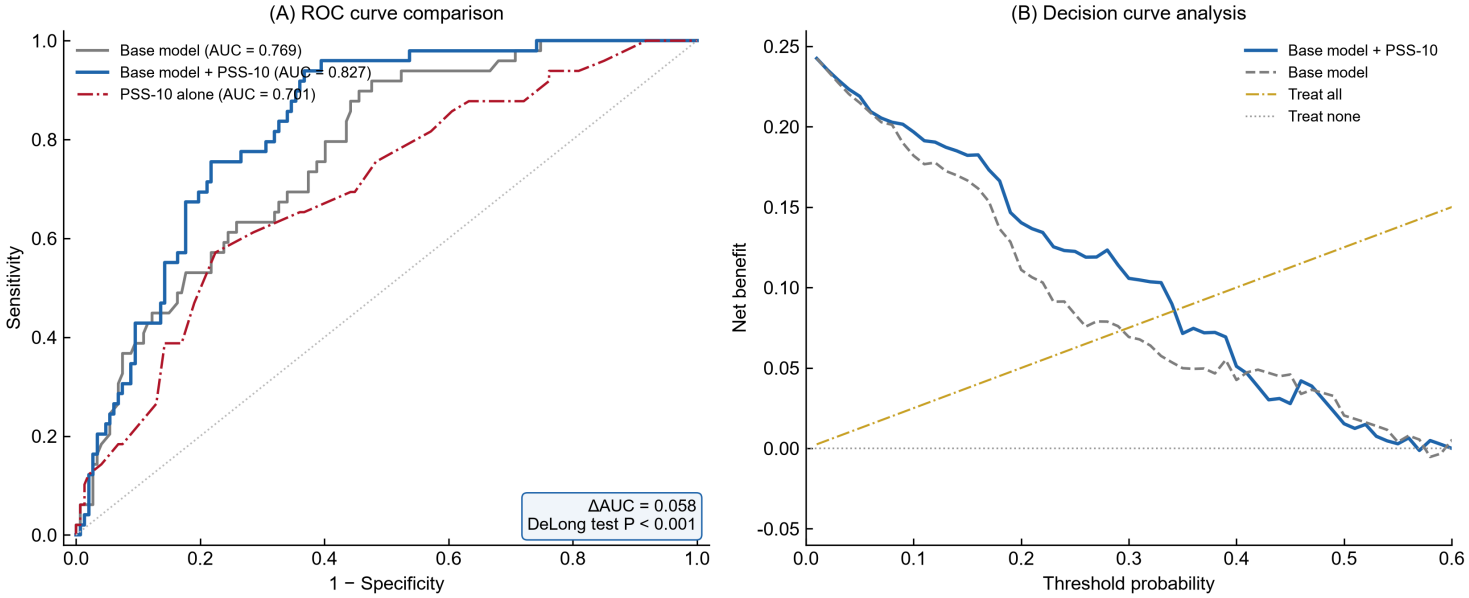



**Figure 3**

Receiver operating characteristic curve of PSS-10 for screening impaired AF-specific quality of life.




## Figure 4

Incremental screening value of PSS-10: (A) comparison of ROC curves between the base and combined models; (B) decision curve analysis.