

Original Article

Managing With Atrial Fibrillation: An Exploratory Model-Based Cluster Analysis of Clinical and Personal Patient Characteristics

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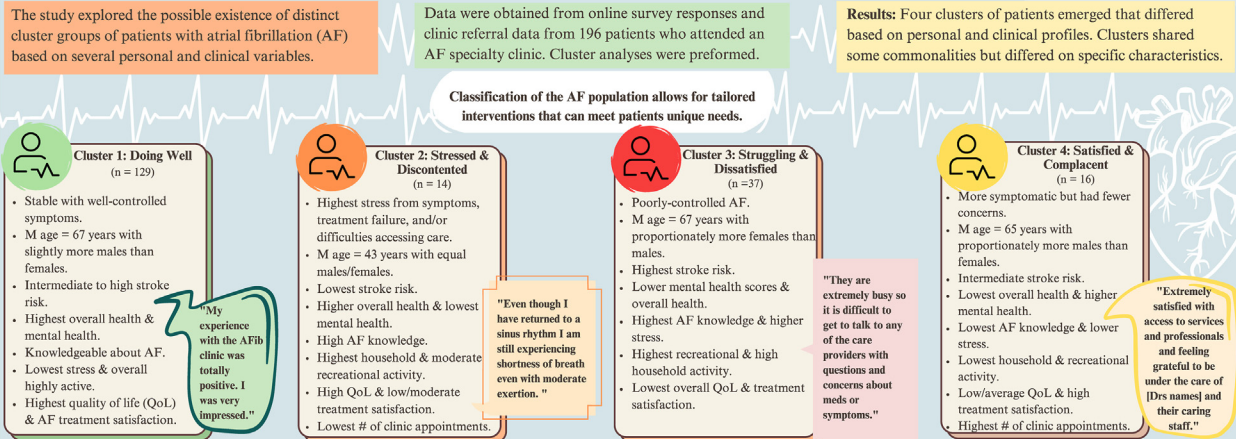
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ABSTRACT

Background: Examining characteristics of patients with atrial fibrillation (AF) has the potential to help in identifying groups of patients who might benefit from different management approaches.

Methods: Secondary analysis of online survey data was combined with clinic referral data abstraction from 196 patients with AF attending an AF specialty clinic. Cluster analyses were performed to identify distinct,

RÉSUMÉ

Contexte : L'examen des caractéristiques des patients atteints de fibrillation auriculaire (FA) pourrait permettre de mieux cerner les groupes qui pourraient bénéficier de différentes approches de prise en charge.

Méthodologie : Nous avons combiné une analyse secondaire de données issues d'un sondage en ligne et les données issues de

Atrial fibrillation (AF), the most common arrhythmia in the general population, is associated with a 5-fold increase in stroke.¹⁻³ Characterized by symptoms that

include irregular heartbeat, fatigue, and shortness of breath, AF significantly impacts quality of life.⁴ Despite all being classified as one disease, different AF subtypes,

homogeneous clusters of AF patients defined by 11 relevant variables: CHA₂DS₂-VASc score, age, AF symptoms, overall health, mental health, AF knowledge, perceived stress, household and recreation activity, overall AF quality of life, and AF symptom treatment satisfaction. Follow-up analyses examined differences between the cluster groups in additional clinical variables.

Results: Evidence emerged for both 2- and 4-cluster solutions. The 2-cluster solution involved a contrast between patients who were doing well on all variables (n = 129; 66%) vs those doing less well (n = 67; 34%). The 4-cluster solution provided a closer-up view of the data, showing that the group doing less well was split into 3 meaningfully different subgroups of patients who were managing in different ways. The final 4 clusters produced were as follows: (i) doing well; (ii) stressed and discontented; (iii) struggling and dissatisfied; and (iv) satisfied and complacent.

Conclusions: Patients with AF can be accurately classified into distinct, natural groupings that vary in clinically important ways. Among the patients who were not managing well with AF, we found 3 distinct subgroups of patients who may benefit from tailored approaches to AF management and support. The tailoring of treatment approaches to specific personal and/or behavioural patterns, alongside clinical patterns, holds potential to improve patient outcomes (eg, treatment satisfaction).

l'orientation clinique de 196 patients atteints de FA d'une clinique spécialisée en FA. Des analyses par grappes ont été réalisées pour cerner des groupes homogènes et distincts de patients atteints de FA, définis grâce à 11 variables pertinentes : score CHA₂DS₂-VASc, âge, symptômes de FA, état de santé général, état de santé mentale, niveau de connaissances sur la FA, niveau de stress perçu, activités récréatives et domestiques, qualité de vie générale avec la FA, et satisfaction concernant le traitement des symptômes de FA. Des analyses ultérieures ont permis de se pencher sur les différences entre les groupes pour d'autres variables cliniques.

Résultats : Deux solutions de regroupement des patients sont apparues possibles à l'analyse : en 2 groupes ou en 4 groupes. Le regroupement en 2 groupes mettait en relief le contraste entre les patients qui avaient des résultats favorables pour tous les paramètres (n = 129; 66 %) et ceux qui avaient des résultats moins favorables (n = 67; 34 %). Le regroupement en 4 groupes permettait d'observer les données plus en détail, et démontrait que le groupe avec des résultats moins favorables se subdivisait en 3 sous-groupes avec des distinctions pertinentes, qui vivaient leur maladie de façon différente. Les 4 groupes finaux étaient les suivants : (i) patients avec une expérience positive; (ii) patients vivant du stress et du mécontentement; (iii) patients vivant des difficultés et une insatisfaction; et (iv) patients vivant une satisfaction complaisante.

Conclusions : Les patients atteints de FA peuvent être classés avec exactitude dans des groupes naturels distincts dont les différences sont d'intérêt clinique. Parmi les patients chez qui la prise en charge de la FA n'est pas optimale, il existe 3 sous-groupes différents qui pourraient tirer profit d'une approche de soutien et de prise en charge adaptée à leur profil. La personnalisation des approches thérapeutiques selon le type de comportements et de traits de personnalité, en plus du tableau clinique, pourrait permettre d'améliorer les résultats des patients (p. ex. la satisfaction par rapport au traitement).

such as valvular and nonvalvular AF, are associated with differing risks of complications.⁵ Beyond these subtypes, considerable variability/heterogeneity exists in patients' AF symptomatology, treatment response, and risk factors.^{4,6} Recently, researchers have recognized the importance of profiling this complex patient population to better understand subgroups and associated outcomes. Cluster analyses have been shown to facilitate the novel categorization of populations with a mixture of complex characteristics.⁷ For heterogenous AF patients, such classifications have the potential to be highly informative in guiding interventions that can be tailored to meet the unique needs of patients with AF.

Several studies have analyzed combinations of complex characteristics, to phenotype patients with AF. Clusters have been reported for symptoms in hospitalized adults with persistent AF,⁸ health and quality-of-life trajectories of

patients receiving care at AF clinics,⁹ risk patterns in older adults with AF,⁷ and illness representations and cognitive-behavioral responses to AF symptoms.¹⁰ Such clustering has been described as clinically significant for identifying patients who are at risk of poor health outcomes,¹⁰ prioritizing treatment approaches,⁷ and ensuring that treatment strategies are appropriate.⁹ Yet, with the exception of Taylor et al.,¹⁰ the emphasis in previous research has been on clinical characteristics, with limited consideration of additional patient characteristics other than sex and age. Despite this, the Ferrans et al. (2005)¹¹ revised version of Wilson and Cleary's model suggested that "personal characteristics" together with "clinical characteristics" are important to quality of life. Still, few studies have considered personal (and potentially modifiable) patient characteristics in the AF population *in combination with* clinical characteristics. For example, perceived stress,^{12,13} physical activity and/or exercise,^{14,15} and knowledge¹⁶ are modifiable and are highly relevant to patients living with AF. By integrating both personal and clinical characteristics, clustering offers the potential for broader profiling, and in turn, the tailoring of approaches beyond the treatment-related emphasis in AF management. The current research aims to address this gap through the inclusion of both clinical and personal variables to explore the possibility of the existence of distinct clusters of AF patients.

The research question that guided this study was as follows: Can meaningful groups of AF patients who vary

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in their profiles of clinical and personal variables be identified?

Material and Methods

Study design and setting

Secondary analysis of data collected using an online cross-sectional survey of patients with AF attending a highly specialized AF clinic in an urban area of Western Canada was combined with data abstracted from clinician referral letters. Upon referral, the specialty clinic provides integrated care, including tests, education, disease management, acute interventions, and advanced treatments; about half of all patients are referred for ablation consultation. The clinic's multidisciplinary team includes cardiologists and electrophysiologists, as well as registered nurses, pharmacists, and nurse practitioners.

Ethical considerations

Ethics approval for the study was granted by the University of British Columbia—Okanagan Behavioural Research Ethics Board (#H19-03601). Prior to completing the survey, all participants provided informed consent, including agreeing to release their AF clinic referral letter to the research team. Participants could choose to be entered in a drawing for 1 of 3 CAD\$150 gift certificates.

Sample and recruitment

All patients of an urban-based AF clinic in Western Canada who were aged over 18 years were eligible to participate. A clinic booking clerk sent information to all patients with upcoming appointments during the course of the recruitment period. A research team member phoned patients, inviting their participation. Interested patients were sent the link to the survey by e-mail.

Data collection

Study data were collected through an approximately 30-minute online survey (see Rush et al.¹⁷ for more detail). Selection of measures (ie, clinical and personal/behavioural variables) was guided by the Ferrans et al. (2005) framework. Clinical data were obtained via chart review.

Measures

All study measures are described in detail in Table 1. In brief, clinical data included Congestive Heart Failure, Hypertension, Age (≥ 75 years), Diabetes Mellitus, Stroke/Transient Ischemic Attack, Vascular Disease, Age (65-74 years), Sex (Female) score (CHA₂DS₂-VASc), number of chronic health conditions, number of medications, total number of encounters with the specialty clinic and date of first appointment, type and severity of AF, treatments and/or intervention history and presence of mental health concern(s), along with one self-report clinical measure—time since last AF symptoms. Personal self-reported data and measures included sociodemographic characteristics, overall health/mental health, AF knowledge, perceived stress, household and

recreational physical activity, health-related quality of life (HRQoL), and AF symptom treatment satisfaction. Finally, patients were asked an open-ended question about their experiences with the AF clinic.

Data cleaning

Of the 196 participants who completed the survey, less than 1% of data were missing for variables included in the analyses. Missing survey data were replaced using multiple imputation³¹ of individual survey items or total scale scores where necessary. Missing clinic and/or referral data varied from 0.0% (number of encounters with specialty clinic) to 50.5% (type and/or nature of AF), and were retained as missing.

Analysis

SPSS (version 28, IBM, Armonk NY) and the factoextra and mclust packages in R³²⁻³⁴ were used to conduct analyses. Cluster analysis is a data-driven approach to explore the possibility of the existence of distinct, homogeneous subgroups within a given selection of variables. Our analysis included 11 variables, as follows: CHA₂DS₂-VASc, age, AF symptoms, overall health, mental health, AF knowledge, perceived stress, and household and recreation activity, overall AF quality of life (QoL), and AF symptom treatment satisfaction. Two quite different cluster analysis methods were selected to reveal whether distinct, homogeneous subgroups of AF patients exist. First, a traditional hierarchical cluster analysis³⁵ was used to generate a dendrogram to explore the number of clusters. Dendrograms are tree or branch diagrams that show the hierarchical relationship between groups of participants; each branch represents groups or clusters of similar participants. Dendrograms are inspected visually for the point at which the vertical segments (ie, distance between clusters) are highest, as a way of inferring the optimal number of clusters evident in the data. Second, model-based cluster analyses using finite mixture modeling (FMM), currently the most popular approach to clustering,³⁶ were conducted to provide confirmation of the findings from the hierarchical cluster analyses. The FMM analyses provided fit statistics for 1- to 15-cluster models, which are useful supplements to traditional cluster analysis procedures that are based on visual inspections. We combined a more traditional hierarchical method (to generate the dendrogram) with the newer, increasingly preferred FMM analyses, in order to confirm our cluster results. Because the response scales for variables varied widely (eg, 1 to 4 scale and 0 to 100 scales), the analyses were conducted on the *z* scores for the variables to facilitate interpretation of the cluster profiles. Variables with ordinal response scales were treated as continuous variables, with time since AF symptoms coded as 0-6 (higher numbers indicating a longer time since last AF symptoms), and overall and mental health coded as 1-4 (higher numbers indicating better health).

Follow-up analyses of variance were used to determine whether clusters differed in number of chronic health problems, number of medications, number of appointments, weeks since first appointment, severity of AF, and number of previous cardioversions, and follow-up Fisher's exact tests were used for type and/or nature of AF (paroxysmal/

Table 1. Summary of study measures

Name	Description	Score range	Score calculation	Psychometric/interpretation information
Clinical data				
CHA ₂ DS ₂ -VASc	The CHA ₂ DS ₂ -VASc score provides an estimate of stroke risk for AF patients, with higher scores associated with higher stroke risk. ¹⁸	The total score ranges from 0 to 9	The CHA ₂ DS ₂ -VASc scores were calculated following the scoring system established by Lip et al. ¹⁹ If the patient had a history of congestive heart failure, hypertension, diabetes mellitus, or vascular disease, as indicated in the referral letter, or if they were age 65–74 years or female, one point per parameter was added to the score. Previous stroke/transient ischemic attack or patient age over 75 years added 2 points per parameter to the score. A total of 25% of patient referral data did not include information about chronic conditions or disease history, and scores for these patients were calculated based solely on age and sex.	A score of 0 carries a risk of .66% per year (considered low risk); a score of 1 is considered intermediate with a risk of 1.45% per year; and any score above 1 is considered high risk, ranging from 2.92% for a score of 2 to 15.89% annual risk for a score of 9. ²⁰
Number of chronic health conditions	As reported by the referring clinician	The total number ranges from 0 to 9*	Scores were the sum of the patient's chronic health conditions	Not applicable
Number of medications	As reported by the referring clinician	The total number ranges from 0 to 10*	Scores were the sum of the patient's medications	Not applicable
Total number of encounters with the AF specialty clinic (eg, appointments, services, call-backs)	Obtained according to the AF clinic records	The total number ranges from 1 to 58*	Scores were the sum of the total number of encounters. Encounters per week variable was calculated by dividing total number of encounters with total weeks since first appointment.	Not applicable
Date of first appointment	Date was obtained from AF clinic records.	The dates range from November 9, 2010 to December 14, 2021	Not applicable	Not applicable
Type of AF	Characterization of AF type as reported by referring clinician.	Not applicable	AF was characterized as "paroxysmal," "persistent," or "permanent."	Not applicable
Severity of AF	Characterization of AF severity as reported by referring clinician	The level of severity ranges from "0 (asymptomatic)" to "3 (severe)"	Clinician characterized patient AF severity as "asymptomatic (0)," "mild (1)," "moderate (2)," or "severe (3)."	Not applicable
AF treatment intervention history	As indicated by the referring clinician	Number of previous cardioversions ranged from 0 to 6*	Whether the patient had previously had an ablation (yes/no), number of cardioversions, and whether on anticoagulants (yes/no)	Not applicable
Presence of mental health concern(s)	If referring clinician indicated that patient had PTSD, depression, OCD, ADHD, BPD, or problematic alcohol use at time of referral	Not applicable	Patient was given a dichotomous score based on the presence (1) or absence (0) of one or more mental health concerns.	Not applicable
Self-report clinical measures				
Time since last AF symptoms	Participants were asked "When was the last time you were aware of having an episode of atrial fibrillation?"	The time since ranges from "1 (currently in AF/earlier today)" to "6 (I was never aware of having AF)"	Ordinal response choices included currently in AF or earlier today (1), within the past week (2), within the past month (3), 1 month to 1 year ago (4), more than 1 year ago (5), and I was never aware of having AF (6). ²¹	Not applicable

Self-reported measures

<p>Sociodemographic characteristics Overall health and mental health</p>	<p>Age, sex, marital status, race/ethnicity, education, and income Participants were asked “How would you rate your overall health?” and “How would you rate your overall mental health?”</p>	<p>Not applicable The score ranges from “1 (poor)” to “4 (excellent).”</p>	<p>Not applicable Questions included 4 response options as follows: 1 (poor); 2 (fair); 3 (good); and 4 (excellent).</p>	<p>Not applicable Single-item measures of self-rated health/mental health are widely used, and have demonstrated moderate correlations with multi-item scales, as well as associations with poor physical health and increased health service utilization.²²</p>
<p>AF knowledge</p>	<p>The knowledge about AF tool is a 24-item questionnaire including questions about AF symptoms, treatment, medications, risk factors, and lifestyle²³</p>	<p>The score ranges from 0 to 100.</p>	<p>In the questionnaire, 3 multiple-choice options are provided, one of which is correct. Participants were given 1 point if the correct answer was chosen, and no points if a wrong answer was selected. Knowledge scores were calculated as a percentage (sum of correct answers divided by 24 multiplied by 100).</p>	<p>Higher percent scores indicate a higher level of knowledge. The knowledge about AF questionnaire has demonstrated content validity, factor validity, known group validity, convergent validity, and high reliability (eg, internal consistency reliability coefficient of .86).²³</p>
<p>Perceived stress</p>	<p>The abbreviated PSS-10 measures the degree to which situations in one’s life are appraised as stressful, ability to control aspects of life, confidence in handling problems, and being unable to cope with demands.</p>	<p>The score ranges from 0 to 40.</p>	<p>Participants responded to items on a scale ranging from never (0) to very often (4). Scores on the positive items were reversed, and responses were summed to create total scores.</p>	<p>Higher participant scores reflect greater perceived stress. Originally developed as a 14-item scale,²⁴ the 10-item version has higher psychometric properties^{25,26}. A 2012 review identified 19 studies that together had established internal consistency, factorial reliability, and known group, criterion, and convergent validity of the PSS-10.²⁷</p>
<p>Household and recreational physical activity</p>	<p>The Phone-FITT questionnaire²⁸ is used to measure both household and recreational physical activity. The questionnaire was adapted for use in an online survey.</p>	<p>The lowest possible score is 0. However, the maximum score is participant dependent.</p>	<p>Participants were asked to indicate their participation in various household and recreational activities in a typical week within the past month and to provide a frequency (times per week), as well as choose a duration from 1 (1–15 minutes) to 4 (1 hour or more) and an intensity from 1 (breathing normally and able to carry on a conversation) to 3 (too out of breath to carry on a conversation). Scores are calculated as the sum of the frequency, duration, and intensity for activities.</p>	<p>Higher scores indicate higher physical activity. The questionnaire has demonstrated good reliability (test–retest coefficients of .84 and .85 for the household and recreational subscales, respectively), fair content validity, and good convergent validity (ie, correlations with accelerometer counts of 0.30 and 0.45 for the household and recreational subscales, respectively)^{28,29}</p>

Continued

Table 1. Continued.

Name	Description	Score range	Score calculation	Psychometric/interpretation information
AFEQT	The AFEQT is a 20 item, 7-point scale with 4 domains: symptoms, daily activities, treatment concerns, and AF symptom treatment satisfaction.	The score ranges from 0 to 100	Overall AFQoL scores are calculated as the sum of items 1–18, accounting for unanswered items, and normed on a scale from 0 to 100. Treatment satisfaction scores follow the same calculation for items 19 and 20.	Higher scores indicate higher AFQoL and higher treatment satisfaction levels. The AFEQT was the most frequently used measure for assessing QoL among patients with AF and was reported to have strongest measurement properties of 6 instruments assessed ¹⁰ and has demonstrated validity (eg, known group validity, convergent, divergent, and factorial validity) and reliability (eg, Cronbach alpha > .88 for all subscales, test-retest reliability > 0.7 for all subscales). ²¹
Self-reported open-ended response				
Patient treatment experiences	Participants were asked “Do you have anything else you would like to share with the research team regarding your experience with the Atrial Fibrillation Clinic?”	Not applicable	Open-ended responses were reviewed. Informative quotes were extracted based on the clusters of participants.	Not applicable

ADHD, attention deficit hyperactivity disorder; AF, atrial fibrillation; AFETQ, Effect on Quality-of-Life Questionnaire; AFQoL, AF-related quality of life; BPD, bipolar disorder; CHA₂DS₂-VASc, Congestive Heart Failure, Hypertension, Age (≥75 years), Diabetes Mellitus, Stroke/Transient Ischemic Attack, Vascular Disease, Age (65–74 years), Sex (Female) score; OCD, obsessive compulsive disorder; Phone-FIT, Brief Physical Activity Interview for Older Adults; PSS-10, 10-item perceived stress scale; PTSD, post-traumatic stress disorder.

*The range is specific to what was found in the present sample of participants.

persistent), treatments and/or intervention history, and presence of mental health concern(s), given the large amount of missing data for these variables. A Fisher exact test was used to determine whether the clusters differed significantly by sex. Follow-up analyses of variance controlling for sex and age were also conducted, comparing clusters on all study variables, and yielded a similar pattern of results, so unadjusted means are presented for simplicity. Two-tailed *P*-values less than 0.05 were considered statistically significant.

Clusters were labelled according to their pattern of composite characteristics relative to the other clusters. The labels were generated to reflect the most distinct differences in characteristics between the clusters in scores on the variables included. Open-ended responses were categorized according to the participant's cluster affiliation and examined by 2 research team members (C.L.S., K.L.R.). Quotes from cluster members were chosen using consensus to illustrate representative characteristics of the clusters.

Results

Characteristics of the study population

During the 1-year recruitment period, 579 patients were eligible for inclusion, and 352 (61%) agreed to be sent the online survey link. Of those, 196 (56%) completed the survey. Participants were an average age of 65.3 years (range 33 to 91 years, standard deviation = 10.3), were primarily male (*n* = 123; 63%), were Caucasian (*n* = 176; 90%), were married or common law partners (*n* = 146; 75%), had professional degrees (*n* = 129; 66%), and had income over \$75,000 (*n* = 99; 51%). Self-report variables are described in Rush et al.,¹⁷ and clinical characteristics of the study population are presented in Table 2.

The mean number of encounters with the specialty clinic was 15 (range: 1 to 58). The mean overall weeks since the first appointment with the AF speciality clinic was 106 weeks (range: 0 to 526). Note that 41 patients were re-referrals, and referral data were extracted from their most recent referral. Clinic participation time was positively associated with the number of appointments (Spearman *r* = 0.58, *P* < 0.001).

Cluster analysis

The horizontal distances in the dendrogram from the Ward hierarchical cluster analysis indicated both 2- and 4-cluster solutions (see Fig. 1). In the 4-cluster solution, one of the groups in the 2-cluster model split into 3 clusters.

The 2 best-fitting models generated by the FMM analyses were for 2- and 4-cluster solutions. The Bayesian information criterion values for these models were more than 10 points better than the coefficients for alternative models, indicating superior model fit. Furthermore, for the 4-cluster solution, the average of the classification uncertainties (0.02), and the average of the highest classification probabilities (0.98) indicated exceptionally clean and distinct cluster groupings. Highly similar values emerged for the 2-cluster solution (0.01 and 0.99). In summary, converging findings resulted from the traditional and model-based cluster analyses, which both

Table 2. Participant clinical characteristics

Characteristics	All participants (n = 196) M (SD)	Sex		P*	Cohen's d
		Male (n = 123) M (SD)	Female (n = 73) M (SD)		
CHA ₂ DS ₂ -VASc	1.59 (1.20)	1.15 (1.11)	2.33 (0.96)	< 0.001	-1.11
Number of chronic health problems (eg, hypertension, diabetes) (n = 41 missing)	2.45 (1.73)	2.48 (1.87)	2.38 (1.51)	0.725	0.06
Number of medications (n = 49 missing)	2.87 (2.10)	2.79 (2.24)	2.98 (1.90)	0.591	-0.09
Weeks since 1st appointment	106.19 (132.78)	108.86 (131.97)	101.70 (134.92)	0.716	0.05
Total number of encounters with clinic	14.92 (13.14)	15.22 (12.75)	14.42 (13.85)	0.683	0.06
Number of encounters per week	1.31 (3.18)	1.35 (3.57)	1.25 (2.42)	0.824	0.03
	n (%)	n (%)	n (%)	P[†]	Cramer's V
Time since last AF symptoms				0.402	0.16
Today (1)	50 (25.5)	31 (25.2)	19 (26.0)		
Within the past wk (2)	35 (17.9)	22 (17.9)	13 (17.8)		
Within the past mo (3)	30 (15.3)	16 (13.0)	14 (19.2)		
1 mo to 1 y ago (4)	50 (25.5)	37 (30.1)	13 (17.8)		
More than 1 y ago (5)	23 (11.7)	12 (9.8)	11 (15.1)		
I was never aware of having AF (6)	8 (4.1)	5 (4.1)	3 (4.1)		
Type of AF				0.165	0.23
Paroxysmal	67 (69.1)	36 (65.5)	31 (73.8)		
Persistent	26 (26.8)	17 (30.9)	9 (21.4)		
Permanent	2 (2.1)	0 (0.0)	2 (4.8)		
Other ('exercise-induced', 'typical')	2 (2.1)	2 (3.6)	0 (0.0)		
n = 99 missing					
Severity				0.677	0.12
Asymptomatic (0)	5 (4.8)	2 (2.9)	3 (8.3)		
Mild (1)	42 (40.0)	28 (40.6)	14 (38.9)		
Moderate (2)	41 (39.0)	28 (40.6)	13 (36.1)		
Severe (3)	17 (16.2)	11 (15.9)	6 (16.7)		
n = 91 missing					
Previous ablation				0.535	0.06
Yes	33 (25.8)	19 (23.8)	14 (29.2)		
No	95 (74.2)	61 (76.3)	34 (70.8)		
n = 68 missing					
Previous cardioversion				0.098	0.15
Yes	60 (46.2)	34 (40.5)	26 (56.5)		
No	70 (53.8)	50 (59.5)	20 (43.5)		
n = 66 missing					
Anticoagulants				0.494	0.07
Yes	93 (62.4)	49 (58.3)	41 (68.3)		
No	56 (37.5)	35 (41.7)	1 (31.7)		
n = 47 missing					
Presence of mental health concerns				1.0	0.01
Yes	6 (3.2)	4 (3.4)	2 (2.9)		
No	183 (96.8)	115 (96.6)	68 (97.1)		
n = 7 missing					

AF, atrial fibrillation; CHA₂DS₂-VASc, Congestive Heart Failure, Hypertension, Age (≥75 years), Diabetes, Stroke/Transient Ischemic Attack, Vascular Disease, Age (65-74 years), Sex (Female) score; M, mean; SD, standard deviation.

* From independent samples *t*-tests.

† From Fisher-Freeman-Halton and Fisher's exact tests.

indicated that 2- and 4-cluster solutions provide credible models for the data. Supplemental Figure S1 displays the profiles of the 2-cluster solution, and Supplemental Figure S2 displays the 4-cluster solution using *z*-scores for comparability.

Table 3 displays the cluster means and *P*-values for all variables. Clusters differed on all 11 variables included in the clustering analyses, with some differences being larger than others (as described below). In follow-up analyses, the clusters did not differ on the number of medications, weeks since first appointment with the AF specialty clinic, severity of AF

symptoms, or number of previous cardioversions but they did differ on the total number of appointments (see Table 3). No cluster differences were present in type and/or nature of AF (ie, paroxysmal or persistent), previous ablation, use of anti-coagulants, or presence of mental illness. The clusters differed significantly by sex; Fisher exact = 8.61, *P* = 0.032, with 85 of the male patients (69%) in cluster 1 (vs 44 female patients; 60%), 9 male patients in cluster 2 (7%) (vs 5 female patients; 7%), 16 male patients (13%) in cluster 3 (vs 21 female patients; 29%), and 13 male patients (11%) in cluster 4 (vs 3 female patients; 4%).

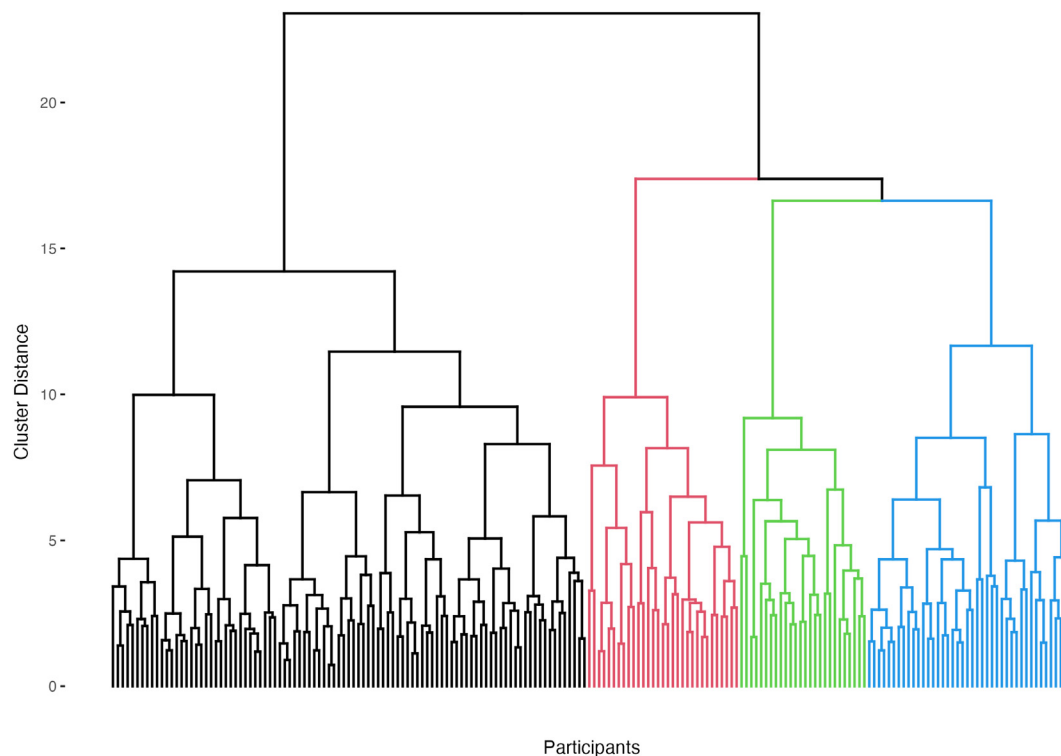


Figure 1. Dendrogram generated using hierarchical cluster analysis using Ward's method and Euclidean distance to explore the number of clusters. Ward's method is an exploratory, agglomerative approach that maximizes differences between clusters while minimizing variability within clusters.³⁵ The 2-cluster solution is displayed as the black group vs the combined colors group, whereas the 4-clusters are each displayed in different colors.

The cluster differences are described along with cluster-specific quotes from the open-ended survey responses.

Cluster 1 (doing well)

Patients in this cluster ($n = 129$) were of average age, had intermediate to high stroke risk, had last AF symptoms more than 1 month previously, had the highest overall and mental health state, had good knowledge of AF, had lowest stress, were highly active, and had the highest quality of life and AF treatment satisfaction. This group appeared to be stable with well-controlled symptoms, and good physical and mental health, and were knowledgeable about AF. Slightly more of the patients in this cluster were male (69%) vs female (60%).

About half (49.6%) contributed open-ended responses. A 69-year-old male participant said "My experience with the AFib clinic was totally positive. I was very impressed"; and a 90-year-old female participant said "Have felt the AFib clinic has been very attentive and helpful." Some reported confidence in their care providers, such as a 70-year-old male describing how the "heart specialist will without a doubt fix this little bump on the road," and some appreciated being able to access detailed information and ask questions (eg, "I very much appreciated [receiving] basic info which I somehow missed. I also appreciated being able to call and have several questions answered before and after my ablation" (67-year-old male).

Cluster 2 (stressed and discontented)

This group ($n = 14$) was the youngest, had the lowest stroke risk, had their last AF symptoms more than 1 month previously, had high knowledge of AF, had the most stress, had the lowest mental health scores, had the highest household activity, had low or average recreational activity, had high QoL, had low or moderate treatment satisfaction, and had the least number of appointments. This cluster had equal percentages of male and female patients (7% each).

About one third (35.7%) of these participants provided open-ended text responses. Participants experienced stress related to recurring or ongoing symptoms, treatment failure, and/or difficulties accessing follow-up care. A 42-year-old male patient recounted access challenges with symptom recurrence, as follows:

"Two days after speaking with my cardiologist [re a management plan and stress test] I had a second occurrence, which again required cardioversion. I reached out to the office to try and arrange another appointment, to discuss whether or not anything should be changed, based on this second episode, but . . . I cannot get any type of communication with my cardiologist."

A 61-year-old male patient described his stress and discontentment as follows:

". . . even though I have returned to a sinus rhythm I am still experiencing shortness of breath even with moderate exertion. It takes too long to affect treatment regimens and the continuum of care and treatment is disjointed and inconsistent."

Table 3. Table of cluster means and P values

	Cluster 1 (n = 129; 65.8%)	Cluster 2 (n = 14; 7.1%)	Cluster 3 (n = 37; 18.9%)	Cluster 4 (n = 16; 8.2%)	P	Partial η^2 *
Results of clustering						
CHA ₂ DS ₂ -VASc	1.62	.71	2.08	1.00	< 0.001	0.09
Age	67.36	42.50	66.78	65.00	< 0.001	0.39
Time since last AF symptoms	3.19	3.21	1.97	2.75	< 0.001	0.10
Overall health	2.92	2.86	2.65	2.50	0.033	0.05
Overall mental health	3.35	2.93	3.05	3.25	0.025	0.05
AF knowledge	84.33	85.42	89.30	55.99	< 0.001	0.48
Perceived stress	11.25	17.36	14.65	13.00	< 0.001	0.09
Household activity	32.74	34.50	33.45	14.88	0.001	0.16
Recreational activity	35.73	31.13	48.14	27.00	< 0.001	0.08
Overall AF quality of life	75.20	74.07	57.28	61.49	< 0.001	0.12
AF symptom treatment satisfaction	87.07	62.50	32.43	72.96	< 0.001	0.66
Results of follow-up comparisons						
# of chronic health problems	2.53	1.78	2.40	2.30	0.648	0.01
# medications	3.04	1.50	2.93	2.73	0.120	0.04
Weeks since 1st appointment	121.34	50.86	74.60	105.56	0.101	0.03
Total # of encounters with clinic	15.75	6.00	14.14	17.88	0.047	0.04
Number of encounters per wk	1.01	1.62	2.32	1.15	0.170	0.03
Severity of AF (0–3)	1.59	1.50	1.85	2.0	0.315	0.03
# of cardioversions	0.65	0.91	0.68	0.64	0.872	0.01

Model-based cluster analyses using finite mixture modeling was conducted with 11 variables; this is an increasingly preferred cluster analysis because it allows for possible variation in cluster sizes and shapes, while providing model fit coefficients for the many possible cluster solutions.³⁶

AF, atrial fibrillation; CHA₂DS₂-VASc, Congestive Heart Failure, Hypertension, Age (≥ 75 years), Diabetes, Stroke/Transient Ischemic Attack, Vascular Disease, Age (65–74 years), Sex (Female) score.

* Partial η^2 values were generated from follow-up analyses of variance comparing clusters on all outcome variables. Analyses of variance controlling for age and gender were also conducted for all outcome variables with no differences in the pattern of results, so unadjusted scores are presented.

Cluster 3 (struggling and dissatisfied)

Patients in this group (n = 37) had the highest stroke risk, the highest average age, the most AF symptoms within the past week or more frequently, high stress, the highest knowledge level, and the highest level of recreational activity with the second-lowest level of mental health, the lowest overall QoL and very low treatment satisfaction. This cluster includes proportionately more female patients (29%) than male patients (13%). This group appeared to be trying to actively self-manage their poorly controlled AF.

Participants in this group shared the highest number of open-ended text comments (n = 19; 51.4%), with many being appreciative about their clinic care but raising some concerns about accessing staff. For example, a 71-year old female patients stated the following: “They are extremely busy so it is difficult to get to talk to any of the care providers with questions and concerns about meds or symptoms . . .” And a 66-year-old male patient suggested that “there is not enough patient time to discuss the details of one’s condition and the optimal therapies available.

Concerns were related to treatments not controlling their symptoms, as a 74-year-old female patient elaborated as follows:

“I have been taking diltiazem for 6 months and continue to be lightheaded, occasionally dizzy and more weak than in the past. I used to be able to have 1 drink, but in the last month, each time I do, I go into Afib. I have had 5 episodes since dec 15th. Previously I would barely have 1 a month. I take flecainide, to control it but it can take up to 4 hours for the hr [heart rate] to come down. The Afib clinic staff have been great in returning my calls re my symptoms, and I have no issues with telehealth. I know in these times it is not realistic, but I wish I could see a cardiologist in person.”

Cluster 4 (satisfied and complacent)

Patients in this cluster (n = 16) were average age, had intermediate stroke risk, had experienced AF symptoms within the preceding month or more frequently, were the group with the lowest level of AF knowledge, had somewhat lower stress, had higher mental health scores, and had the lowest household and recreational activity level. Despite reporting low-level overall health, and average to low QoL, this cluster had high treatment satisfaction and attended the most appointments. This group had proportionately more male patients (11%) than female patients (4%). Members of this cluster, despite being more symptomatic, had the fewest concerns, possibly owing to having low knowledge levels.

Six patients (37.5%) provided comments ranging from having little to say (“nothing” and “I do not experience any symptoms”) to being grateful for the care they were receiving, describing themselves as “extremely satisfied with access to services and professionals and feeling grateful to be under the care of [Drs names] and their caring staff” (69-year-old female). In the latter category, another said he “had one call with the Doctor from AFib Clinic and was happy for it” (62-year-old male patient).

Discussion

This study explored the possibility of the existence of distinct cluster groups of AF patients receiving specialty AF clinic care with varying profiles of clinical and self-reported personal variables. Findings from the cluster analysis provide support for distinct clusters, consistent with other evidence showing the diversity in the AF population relative to various combinations of characteristics.^{8,9} The initial clustering revealed 2 broad groups of AF patients—those doing well (66%) and those doing less well (34%). However, the use of a total of 11 variables provided strong evidence that those in the group doing less well could be further subdivided into 3 subgroups, with patients classified accurately into significantly different profiles. Each of the 3 clusters had differing combinations of measures by which they were doing well and others by which they were not. This nuanced understanding of subgroups of patients with AF receiving specialty care can guide clinicians in providing support specific to the variable needs across subgroups, while leveraging their capacities to address their challenges.

Cluster 1, the largest group and doing well clinically and personally, nevertheless had a moderate-to-high stroke risk and would benefit from continuing reinforcement and support in self-care monitoring, maintenance, and management. Cluster 2, the youngest group, was doing fairly well overall, but had the poorest mental health and the highest stress level of all clusters. The high AF-knowledge scores found in these younger patients may have increased their worries. Additionally, they are at an earlier life stage, so attending to job and family demands, while dealing with the unpredictability of AF, may heighten their stress and influence their coping ability. In addition to standard AF care, these patients may benefit from services focused on supporting their stress and mental health needs.

Cluster 3 was the most symptomatic, had a low level of satisfaction with AF symptom treatment, had a high stress level, were predominantly female, and had the lowest level of mental health and QoL while having the highest level of AF knowledge and high activity scores. Services for patients in this cluster warrant focusing on symptom management, supporting self-care efforts, providing mental health support, and promoting their active involvement in and control over their treatment plan. Shared decision-making to align treatments with personal goals may be especially helpful with this group.^{37,38} Tools for patients and clinicians to facilitate shared decision-making for AF continue to emerge.³⁹

Cluster 4, which had more recently experienced AF symptoms, despite having lower stress and high treatment satisfaction levels, also had the lowest level of AF knowledge

and the lowest activity level. This cluster might benefit from educational support and exercise rehabilitation and/or a progressive physical activity plan to empower self-management to improve AF symptoms. Clinicians might consider implementing collaborative goal setting to encourage patient control, as evidence shows that when this approach is used, patients set priorities and ambitious goals and generate creative and individualized action plans.⁴⁰

HRQoL has been an important focus of research profiling patients with AF. By this measure, we found that 72.9% of patients were doing well (good, not excellent; clusters 1 and 2), and 27.1% were doing poorly (clusters 3 and 4). This finding contrasts with Kwon et al.⁹ who reported that over 60% of their patient population was doing poorly. However, our between-cluster differences were based on variations in multiple characteristics, of which HRQoL was only one. Greater variability was seen in other characteristics, particularly in treatment satisfaction among different clusters. Clusters 1 and 4 were satisfied, whereas clusters 2 and 3 were dissatisfied, as was evident from participants' comments. Our findings imply that focusing solely on isolated characteristics may hinder a comprehensive understanding of the patient experience.

Our measure of effect size (partial η^2) measures the proportion of the variance in each outcome variable that can be accounted for by cluster group membership. Using Cohen's⁴¹ benchmarks to define small ($\eta^2 = 0.01$), medium ($\eta^2 = 0.06$), and large ($\eta^2 = 0.14$) effects, our clusters differed with medium to substantially large effects on many of the included variables. Notably, clusters differed the most in treatment satisfaction, AF knowledge, and age.

AF symptoms reduce HRQoL,⁴ and a meta-analysis found that higher age and female sex were also associated with poorer HRQoL, particularly in the physical domain.⁴² In our study, clusters did not differ significantly by AF type or severity, nor on treatment and/or intervention history. However, clusters 1 and 2 were relatively stable, with their last AF symptoms having occurred more than 1 month previously, whereas clusters 3 and 4 had more recent AF symptoms. Although symptom recency was measured at only one point in time, it provides a window into the patients' symptomology. We found a low level of association between symptoms and treatment satisfaction, with one of the stable clusters (2) reporting a low level of treatment satisfaction, whereas one of the unstable clusters (4) had a high level of treatment satisfaction. This finding demonstrates the importance of considering treatment satisfaction within the context of other patient attributes.

In contrast to previous studies,⁹ we observed significant sex differences between clusters; cluster 3 (struggling/dissatisfied) had proportionately more female patients, and cluster 4 (satisfied/complacent) had proportionately more male patients. Despite sharing similarities on some characteristics (ie, stress, mental health, perception of health), these 2 clusters differed in symptomology, stroke risk, HRQoL, treatment satisfaction, knowledge, and activity. Cluster 3, with proportionately more female patients, had the lowest treatment satisfaction score, compared to the nearly double and triple scores of clusters 1 and 4, which included proportionately more male patients. These observations confirm those of others that female patients with AF experience greater symptom frequency and burden, have a higher stroke risk, have lower QoL, and are often offered fewer treatment options.^{8,43}

Through self-management and by taking an active role in managing their condition,^{44,45} patients can positively impact their symptoms and QoL. Yet, unlike for other cardiac conditions (eg, cardiovascular disease and heart failure), little guidance is available for clinicians that addresses behavioral or emotional contributors to symptoms, as current treatment approaches focus predominantly on heart rhythm and/or rate.⁴⁶ The present clustering of combined clinical and personal characteristics is an initial step toward understanding the unique needs within this complex patient population that can also help inform tailored self-management and interventions and programs. The potential mechanisms underlying the observed between-cluster differences in pattern combinations of clinical and personal characteristics likely reflect complex interactions between physiological and psychological factors and their interplay with treatment interventions and patient responses to treatment.⁴⁷ An emerging body of literature has shown the close interaction between psychological and AF electrophysiological factors, which is important for individualizing treatment and optimizing patients' treatment satisfaction and QoL.⁴⁷ According to the Canadian AF management guidelines, key to self-management is the patient's perceived understanding of the causes and consequences of symptom manifestation, along with perceptions about its controllability.⁴⁸ Misalignment of therapeutic treatment with patient preferences and values can lead to dissatisfaction with therapy.⁴⁸ Future work is needed to explore patient experiences more deeply, to elucidate the potential fundamental factors and/or mechanisms underlying the cluster differences observed in this study.

Strengths and Limitations

Findings from this cluster analysis add to a growing body of evidence advancing an understanding of the heterogeneity among AF patients and the recognition of unique subgroups.^{9,49} Understanding these profiles supports the development of tailored approaches to AF management to address the specific needs of each group. Our results should, however, be interpreted in light of the study's limitations. Our population was predominantly male, Caucasian, married, and highly educated. These patients also received care in a specialty AF clinic, and patients referred to tertiary clinics often have a greater disease burden than do average AF patients.⁵⁰ Analysis on a larger, more diverse sample would increase transferability of findings. Overall, 34% of the eligible patients receiving care at the AF specialty clinic participated in our online survey (potential self-selection bias); however, our patient participants mirrored those in the larger clinic in terms of demographic and clinical characteristics. We relied on clinician referral letters to extract patient history data, resulting in missing data on these clinical variables for up to half of our patients, and thereby reducing our ability to understand disease burden and calculate stroke risk scores. We were unable to cluster patients based on these clinical variables because the large amount of missing data would have resulted in all cases without complete data being dropped. However, the amount of missing clinical data was roughly equal across the 4 clusters, and we were able to include follow-up comparisons of between-cluster differences on these clinical variables. Still,

our smaller sample size limited our ability to thoroughly investigate potential cluster differences among different subgroups of patients with AF (eg, paroxysmal/persistent, impact of psychiatric illness). Future research could address these factors by evaluating whether cluster results remain similar across different subpopulations of patients with AF (eg, those with persistent AF and heart failure) when using larger samples or a tighter selection of patients (eg, populations with AF and psychiatric illness).

The results from a cluster analysis depend on the variables that were used in the analyses. However, measures were selected based on Ferrans et al.'s (2005) model, and our findings support the model's proposition that both clinical and personal variables are important to consider. Further, the clusters that emerged in the present data were meaningful interpretively, and they displayed good fit to the data. The high classification probabilities and/or low uncertainties lead us to expect that the observed cluster groups also are likely to emerge in other datasets.

Conclusions

Using a robust clustering technique, a diverse sample of patients with AF receiving specialty clinic care were classified into 4 groups that differed in their combinations of clinical and personal characteristics. Although the largest group was doing well on all characteristics, the other 3 were not doing as well, sharing some commonalities but differing on specific characteristics that distinguished them from one another. Clusters differed according to age and sex, with more female patients in groups who were doing less well overall than male patients, and with the youngest group experiencing the greatest mental health and coping challenges. These findings have implications for tailoring AF clinic management and support to address the unique needs of patients. Tailored treatment approaches have potential to impact patient outcomes, such as QoL and treatment satisfaction for improved AF management. Due to sample size, we were unable to thoroughly investigate potential cluster differences for different subgroups of patients with AF, an area for future research. Overall, the findings of this study advance knowledge by demonstrating that meaningfully distinct groups of AF patients vary in their profiles of clinical and personal variables. The findings have potential for improving clinical practice by guiding tailored treatment approaches to improving patient outcomes.

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Ethics Statement

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Patient Consent

The authors confirm that patient consent has been obtained for this research.

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References

1. Wolf PA, Abbott RD, Kannel WB. Atrial fibrillation as an independent risk factor for stroke: the Framingham study. *Stroke* 1991;22:983-8.
2. Marini C, De Santis F, Sacco S, et al. Contribution of atrial fibrillation to incidence and outcome of ischemic stroke: results from a population-based study. *Stroke* 2005;36:1115-9.
3. Kannel WB, Abbott RD, Savage DD, McNamara PM. Epidemiologic features of chronic atrial fibrillation: the Framingham study. *N Engl J Med* 1982;306:1018-22.
4. Freeman JV, Simon DN, Go AS, et al. Association between atrial fibrillation symptoms, quality of life, and patient outcomes: results from the Outcomes Registry for Better Informed Treatment of Atrial Fibrillation (ORBIT-AF). *Circ Cardiovasc Qual Outcomes* 2015;8:393-402.
5. Blustin JM, McBane RD, Ketha SS, Wysokinski WE. Distribution of thromboembolism in valvular versus non-valvular atrial fibrillation. *Expert Rev Cardiovasc Ther* 2014;12:1129-32.
6. Cherian TS, Shrader P, Fonarow GC, et al. Effect of atrial fibrillation on mortality, stroke risk, and quality-of-life scores in patients with heart failure (from the Outcomes Registry for Better Informed Treatment of Atrial Fibrillation [ORBIT-AF]). *Am J Cardiol* 2017;119:1763-9.
7. Suzuki S, Yamashita T, Otsuka T, et al. Identifying risk patterns in older adults with atrial fibrillation by hierarchical cluster analysis: a retrospective approach based on the risk probability for clinical events. *Int J Cardiol Heart Vasc* 2021;37:100883.
8. Streur M, Ratcliffe SJ, Callans D, Shoemaker MB, Riegel B. Atrial fibrillation symptom clusters and associated clinical characteristics and outcomes: a cross-sectional secondary data analysis. *Eur J Cardiovasc Nurs* 2018;17:707-16.
9. Kwon JY, Sawatzky R, Baumbusch J, Ratner PA. Patient-reported outcomes and the identification of subgroups of atrial fibrillation patients: a retrospective cohort study of linked clinical registry and administrative data. *Qual Life Res* 2021;30:1547-59.
10. Taylor EC, O'Neill M, Hughes LD, Moss-Morris R. Atrial fibrillation, quality of life and distress: a cluster analysis of cognitive and behavioural responses. *Qual Life Res* 2022;31:1415-25.
11. Ferrans CE, Zerwic JJ, Wilbur JE, Larson JL. Conceptual model of health-related quality of life. *J Nurs Scholarsh* 2005;37:336-42.
12. Rush KL, Hatt L, Shay M, et al. The stressors and coping strategies of older adults with persistent atrial fibrillation prior to and following direct current cardioversion. *J Appl Gerontol* 2017;36:1145-65.
13. Ekblad H, Rönning H, Fridlund B, Malm D. Patients' well-being: experience and actions in their preventing and handling of atrial fibrillation. *Eur J Cardiovasc Nurs* 2013;12:132-9.
14. Chung MK, Eckhardt LL, Chen LY, et al. Lifestyle and risk factor modification for reduction of atrial fibrillation: a scientific statement from the American Heart Association. *Circulation* 2020;141:E750-72.
15. Reed JL, Mark AE, Reid RD, Pipe AL. The effects of chronic exercise training in individuals with permanent atrial fibrillation: a systematic review. *Can J Cardiol* 2013;29:1721-8.
16. Tam W, Woo B, Lim TW. Questionnaires designed to assess knowledge of atrial fibrillation: a systematic review. *J Cardiovasc Nurs* 2019;34:E14-21.
17. Rush KL, Seaton CL, Burton L, et al. Quality of life among patients with atrial fibrillation: a theoretically-guided cross-sectional study. *PLoS One* 2023;18(10):e0291575.
18. Gažová A, Leddy JJ, Rexová M, et al. Predictive value of CHA2DS2-VASc scores regarding the risk of stroke and all-cause mortality in patients with atrial fibrillation (CONSORT compliant). *Medicine* 2019;98:e16560.
19. Lip GYH, Nieuwlaar R, Pisters R, Lane DA, Crijns HJGM. Refining clinical risk stratification for predicting stroke and thromboembolism in atrial fibrillation using a novel risk factor-based approach. *Chest* 2010;137:263-72.
20. Olesen JB, Lip GYH, Hansen ML, et al. Validation of risk stratification schemes for predicting stroke and thromboembolism in patients with atrial fibrillation: nationwide cohort study. *BMJ* 2011;342:1-9.
21. Spertus J, Dorian P, Bubien R, et al. Development and validation of the Atrial Fibrillation Effect on Quality-of-Life (AFEQT) Questionnaire in patients with atrial fibrillation. *Circ Arrhythm Electrophysiol* 2011;4:15-25.
22. Ahmad F, Jhaji AK, Stewart DE, Burghardt M, Bierman AS. Single item measures of self-rated mental health: a scoping review. *BMC Health Serv Res* 2014;14:1-11.
23. McCabe PJ, Sendin MJ, Stuart-mullen L, et al. Initial psychometric testing of the knowledge about atrial fibrillation and self-management survey 2019;35:35-44.
24. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. *J Health Soc Behav* 1983;24:386-96.
25. Taylor JM. Psychometric analysis of the ten-item perceived stress scale. *Psychol Assess* 2015;27:90-101.
26. Cohen S. Perceived stress in a probability sample of the United States. In: Spacapan S, Oskamp S, eds. *The Social Psychology of Health*. Sage, 1988:31-66.
27. Lee EH. Review of the psychometric evidence of the perceived stress scale. *Asian Nurs Res (Korean Soc Nurs Sci)* 2012;6:121-7.
28. Gill DP, Jones GR, Zou G, Speechley M. The phone-FITT: a brief physical activity interview for older adults. *J Aging Phys Act* 2008;16:292-315.
29. Doma K, Speyer R, Parsons LA, Cordier R. Comparison of psychometric properties between recall methods of interview-based physical activity questionnaires: a systematic review. *BMC Med Res Methodol* 2019;19:1-29.
30. Sale A, Yu J. Quality of life instruments in atrial fibrillation: a systematic review of measurement properties. *Health Qual Life Outcomes* 2022;20:1-11.

31. Austin PC, White IR, Lee DS, van Buuren S. Missing data in clinical research: a tutorial on multiple imputation. *Can J Cardiol* 2021;37:1322-31.
32. R Foundation for Statistical Computing. R: A language and environment for statistical computing. Available at: <https://www.r-project.org/>. Accessed April 16, 2023.
33. Scrucca L, Fop M, Murphy TB, Raftery AE. Mclust 5: Clustering, classification and density estimation using Gaussian finite mixture models. *R Journal* 2016;8:289-317.
34. Kassambara A, Mundt F. Factoextra: extract and visualize the results of multivariate data analyses. Version: 1.0.7. Available at: <https://cran.r-project.org/web/packages/factoextra/index.html>. Accessed June 25, 2023.
35. Ward JH, Hook ME. Application of an hierarchical grouping procedure to a problem of grouping profiles. *Educ Psychol Meas* 1963;23:69-81.
36. Dalmaijer ES, Nord CL, Astle DE. Statistical power for cluster analysis. *BMC Bioinformatics* 2022;23:1-28.
37. Elwyn G, Cochran N, Pignone M. Shared decision making—the importance of diagnosing preferences. *JAMA Intern Med* 2017;177:1239-40.
38. Fried TR, Street RL, Cohen AB. Chronic disease decision making and ‘what matters most.’ *J Am Geriatr Soc* 2020;68:477.
39. Fanio J, Zeng E, Wang B, et al. Designing for patient decision-making: design challenges generated by patients with atrial fibrillation during evaluation of a decision aid prototype. *Front Digit Health* 2023;1(4):1-10.
40. Kangovi S, Mitra N, Smith RA, et al. Decision-making and goal-setting in chronic disease management: baseline findings of a randomized controlled trial. *Patient Educ Couns* 2017;100:455.
41. Cohen J. *Statistical Power Analysis for the Behavioral Sciences*. 2nd ed. New York: Routledge, 1988.
42. Zhang L, Gallagher R, Neubeck L. Health-related quality of life in atrial fibrillation patients over 65 years: a review. *Eur J Prev Cardiol* 2015;22:987-1002.
43. Andrade J, Macle L. Addressing extracardiac risk factors to improve atrial fibrillation treatment outcomes. *J InnovCard Rhythm Manag* 2019;10:3881-90.
44. Jovicic A, Holroyd-Leduc JM, Straus SE. Effects of self-management intervention on health outcomes of patients with heart failure: a systematic review of randomized controlled trials. *BMC Cardiovasc Disord* 2006;6:1-6.
45. Richardson J, Loyola-Sanchez A, Sinclair S, et al. Self-management interventions for chronic disease: a systematic scoping review. *Clin Rehabil* 2014;28:1067-77.
46. Hilow HJ, Whibley D, Kratz AL, Ghanbari H. A focus group study to inform design of a symptom management intervention for adults with atrial fibrillation. *Cardiovasc Digit Health J* 2021;2:246-55.
47. Ladwig KH, Goette A, Atasoy S, Johar H. Psychological aspects of atrial fibrillation: a systematic narrative review: impact on incidence, cognition, prognosis, and symptom perception. *Curr Cardiol Rep* 2020;22:137.
48. Andrade JG, Aguilar M, Atzema C, et al. The 2020 Canadian Cardiovascular Society/Canadian Heart Rhythm Society comprehensive guidelines for the management of atrial fibrillation. *Can J Cardiol* 2020;36:1847-948.
49. Lee J, Turchioe MR, Creber RM, et al. Phenotypes of engagement with mobile health technology for heart rhythm monitoring. *JAMIA Open* 2021;4:ooab043.
50. Son YJ, Baek KH, Lee SJ, Seo EJ. Health-related quality of life and associated factors in patients with atrial fibrillation: an integrative literature review. *Int J Environ Res Public Health* 2019;16:3042.

Supplementary Material

To access the supplementary material accompanying this article, visit *CJC Open* at <https://www.cjopen.ca/> and at <https://doi.org/10.1016/j.cjco.2023.08.005>.