

Preferences of Patients and Cardiologists Regarding Pacemaker Characteristics in Spain: A Discrete Choice Experiment

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Purpose: A better understanding of the preferences of patients and cardiologists for pacemaker characteristics is essential for advancing patient-centered care. We therefore aimed to identify and quantify the preference that patients and cardiologists assign to specific characteristics.

Patients and Methods: We conducted an observational, cross-sectional, descriptive study based on a discrete choice experiment (DCE). The design was informed by a literature review, a patient focus group, and a scientific committee.

Results: A total of 42 patients (66.7% male, mean [SD] age 64.2 [12.1] years) and 42 cardiologists (64.3% male, mean age 47.3 [9.3] years) participated in the study. For both patients (P) and cardiologists (C), the most important characteristics of pacemakers (higher relative importance, RI) are MRI compatibility (P: 28.1%; C: 25.1%) and battery longevity (P: 22.6%; C: 23.8%). The type of follow-up is more highly valued by cardiologists than by patients (P: 10.2%; C: 21.1%), whereas pacemaker size is prioritized by patients (P: 19.1%; C: 7.7%). From the cardiologists' perspective, safety (12-month post-implantation infection rate: 19.39%) and technical aspects such as conduction system pacing (CSP) (15.14%), algorithms for minimizing unnecessary right ventricular stimulation (9.43%), and programming modes (9.11%) are also important decision drivers.

Conclusion: MRI compatibility and battery longevity are key factors for both patients and cardiologists in decision-making. Patients also prioritize generator size and replacement processes, while cardiologists additionally focus on safety (infection rates) and technical aspects (CSP and algorithms to reduce unnecessary right ventricular stimulation).

Plain Language Summary: Pacemakers help control abnormal heart rhythms. These devices differ in several features, and both patients and cardiologists may value them differently.

This study explored which pacemaker characteristics are most important to patients and cardiologists. Forty-two patients with pacemakers and forty-two cardiologists participated in a survey that asked them to choose between different device options.

Both groups agreed that MRI compatibility (being safe for magnetic resonance scans) and battery longevity were the most valued characteristics. Patients gave greater importance to the size of the device, preferring smaller generators, while cardiologists placed more value on how follow-up is performed after implantation.

Cardiologists also emphasized safety, such as lowering infection risk after the procedure, and technical aspects, including conduction system pacing and algorithms that help reduce unnecessary right ventricular stimulation.

Overall, the study shows that patients and cardiologists share similar priorities regarding MRI compatibility and battery life, but differ in their focus on other features. Recognizing these differences can help improve communication and support shared decision-making when selecting a pacemaker, ensuring that treatment choices better reflect what matters most to patients.

Keywords: pacemaker, preferences, discrete choice experiment



Introduction

Cardiovascular diseases are the leading cause of morbidity and mortality worldwide, including disorders of the cardiac conduction system that result in bradyarrhythmias and require permanent cardiac pacing.^{1–3} Implantable pacemakers (PM) are an effective treatment for these conditions and have been shown to improve survival and health-related quality of life (HRQoL).^{4–7} Accordingly, PM implantation rates remains high across several European countries,⁸ with the Spanish Pacemaker Registry reporting an implantation rate of 891 units per million population in 2023.⁹

Advances in PM technology have transformed cardiac pacing, evolving from simple single-lead devices (conventional PM) to more sophisticated systems with distinct technical characteristics, such as stimulation modes, sensing capabilities, and implantation approaches.^{10–14} Among these, leadless pacemakers (LLPM) represent a major innovation, offering potential advantages over conventional transvenous PMs in certain clinical scenarios,^{15–18} particularly for patients with limited vascular access and high risk of infection.^{19–24} These devices reduce the complications associated with conventional PM implantation, largely related to the implantation technique, the electrode, and the generator pocket.^{7,25}

Although the benefits of different types of PMs in improving HRQoL and survival are well established, data on how patients and cardiologists value specific PM characteristics remain limited. Understanding these preferences could facilitate the implementation of shared decision-making, a fundamental pillar of patient-centered medicine,^{26,27} especially in cardiology, where therapeutic options available are diverse and complex. Capturing and comparing these preferences provides valuable insight into real-world decision-making and potential mismatches between patient and clinician perspectives. Moreover, patient preferences are increasingly recognized as relevant inputs for clinical guidelines, health technology assessment and healthcare decision-making, supporting more informed and patient-centered decision-making processes.^{28–30}

The aim of this study was to identify and quantify patients' and cardiologists' preferences for PM characteristics.

Materials and Methods

This was a cross-sectional study employing a discrete choice experiment (DCE), led by a scientific committee (SC) consisting of three cardiologists (FJGF, MLFA, FRM) with extensive experience in PM implantation.

Population

Patients aged ≥ 18 years implanted with a PM (conventional or leadless) for at least 12 months were eligible for inclusion. Cardiologists were eligible if they had at least 1 year of experience in the implantation and/or follow-up of conventional PM and LLPM, were actively involved in cardiac pacing, electrophysiology, or arrhythmia units within the Spanish public healthcare system, and had ongoing clinical activity in device implantation. Operator experience was further characterized by years of practice and annual procedural volume.

To obtain a heterogeneous patient sample, participants were identified and invited to take part in the study through the Spanish patient advocacy group CardioAlianza, and recruited during routine clinical practice by the 3 cardiologists serving on the SC.

The SC also identified and invited cardiologists to participate in the study.

According to the rule of thumb proposed by Johnson and Orme,^{31–33} a minimum sample size of 42 participants was estimated.

Discrete Choice Experiment

A DCE is a conjoint analysis technique that enables the identification and analysis of participants' preferences regarding a treatment, intervention, or health product in a relatively straightforward manner,^{34–36} and simulates the process of choosing a treatment or medical device. This is achieved by presenting participants with a series of hypothetical scenarios (choice sets) comprising 2 or more alternatives. These alternatives are derived from the combination of different attributes (or characteristics) of the treatments or health products, along with the respective levels (or values) that each attribute can assume. Participants are then required to select their preferred option from the choice set.^{34,37} The

DCE in this study was conducted following the International Society for Pharmacoeconomics and Outcomes Research (ISPOR) good practice recommendations for conjoint analysis in healthcare.³⁴

To design the choice sets, a literature review was performed and a focus group was held with patients. The literature review in international databases (PubMed/Medline) identified the characteristics (attributes and levels) that describe pacemakers. The information obtained was supplemented with a review of the technical documentation of these devices. A focus group with patients who had undergone pacemaker implantation was subsequently organized to determine which pacemaker characteristics were considered most relevant. The patients who participated in the focus group were identified and invited to participate through CardioAlianza. The SC reviewed and confirmed the attributes and levels identified in the literature and the patient focus group.

Since some of the characteristics included in the scenarios were highly technical and likely to be difficult for patients to understand, it was decided to create two separate DCEs: one for both patients and cardiologists (DCE 1), and another exclusively for cardiologists (DCE 2). The language used in the DCE addressed to patients was adapted to enhance their understanding. Efforts were made to simplify complex terminology and ensure that the choice set and instructions were clear and comprehensible.

Table 1 shows the attributes and levels included in DCE 1 and DCE 2. A common attribute (absence/presence of leads) was included in both DCEs to jointly analyze the preferences of cardiologists. This repeated attribute was intentionally included to allow joint estimation of preferences across DCE blocks and to facilitate comparison of trade-offs under different attribute combinations, in accordance with standard DCE methodology.^{34,38}

To construct the different choice sets, the attributes and levels were combined following ISPOR guidelines,³⁴ ensuring their orthogonality and balance. The orthogonal design guarantees that all attribute levels vary independently,

Table 1 Attributes and Levels Included in DCE 1 (Addressed to Patients and Cardiologists) and DCE 2 (Addressed to Cardiologists)

	Attributes	Levels
DCE 1 and DCE 2	Lead vs leadless pacing	<ul style="list-style-type: none"> • In the absence of leads • By implanting leads
DCE 1	Longevity (battery life)	<ul style="list-style-type: none"> • ≥8 years • <8 years
	Size	<ul style="list-style-type: none"> • Small • Large
	MRI compatibility	<ul style="list-style-type: none"> • MRI compatible • MRI incompatible
	External self-perception	<ul style="list-style-type: none"> • Palpable (subcutaneous) • Non-palpable (intraventricular)
	Generator replacement	<ul style="list-style-type: none"> • It is replaced by a new generator • It is not removed and a new generator is implanted
	Follow-up	<ul style="list-style-type: none"> • In-office follow-up only (no remote follow-up) • In-office and remote follow-up options available
DCE 2	12 months post-implant infection rate	<ul style="list-style-type: none"> • <1.5% • ≥1.5%
	Programming modes	<ul style="list-style-type: none"> • Allows programming of all modes (DDD/R, VDD/R, VVI/R, AAI/R) • Allows programming of only 2 modes (VVI/R and VDD/R)
	CSP	<ul style="list-style-type: none"> • Stimulates the left bundle branch area/His bundle • Does not allow stimulation of the left bundle branch area/His bundle
	Algorithms for minimizing unnecessary right ventricular stimulation	<ul style="list-style-type: none"> • It includes algorithms to minimize unnecessary right ventricular stimulation • It does not include algorithms to minimize unnecessary right ventricular stimulation
	Automatic capture control algorithms	<ul style="list-style-type: none"> • It includes automatic capture control algorithms • It does not include automatic capture control algorithms
	Capability of the programmer to check other pacemaker models	<ul style="list-style-type: none"> • Other pacemaker models • Only the implanted pacemaker model

Abbreviations: AAI/R, single chamber atrial stimulation; CSP, conduction system pacing; DDD/R, sequential stimulation with two leads; MRI, magnetic resonance imaging; VDD/R, single-wire sequential stimulation; VVI/R, single chamber ventricular stimulation.

Table 2 Example of Choice Set in the DCE 1 Addressed to the Cardiologists

	Pacemaker A	Pacemaker B
The pacemaker is Small	... Large
Battery life is ≥8 years	... <8 years
The pacemaker stimulation Requires implantation of leads	... Does not require implantation of leads
Having the pacemaker Is compatible with performing MRIs (under specific conditions)	... Is not compatible with performing MRIs
Due to its location, the pacemaker Is not palpable through the skin (intraventricular)	... Is palpable through the skin (subcutaneous)
When the pacemaker battery (generator) runs out It is not removed and a new generator is implanted	... It is replaced by a new generator
Pacemaker follow-up Is in-office with the possibility of remote follow-up	... Is in-office only, with no possibility of remote follow-up
	I prefer A	I prefer B

while the balance design ensures that each attribute level occurs the same number of times. A total of 12 pairs of choice sets were obtained for each DCE (Table 2).

To ensure that all participants included in the analysis had fully understood the methodology, a choice set with a dominant scenario, depicting the desired levels or characteristics of each PM attribute (Table S1) was also presented along with the rest of the choice sets. Participants were required to respond correctly to this scenario to proceed with the study.

The choice sets included in the DCE 1 and DCE 2 were reviewed by the study SC to ensure their plausibility for the participants and to avoid implausible combinations in the experimental design.^{34,38} Additionally, the choice sets were presented to 3 patients to verify that the attributes and levels included in the scenarios, as well as the language used, were understandable and that they could easily complete the required exercise.

An electronic questionnaire was developed to present the choice sets to participants. This questionnaire also collected patient sociodemographic, clinical and care characteristics, including age, sex, permanent address, level of education, dependence on a PM, and the date of PM implantation. The following variables were collected from cardiologists: age, sex, institutional affiliation and scope of practice (public, private, or mixed healthcare), years of experience in the implantation of conventional PMs and LLPMS, and the approximate number of implants performed in the last year.

Because DCE1 and DCE2 included different sets of accompanying attributes, the relative importance and statistical significance of a given attribute may vary across DCEs, reflecting context-dependent preferences and trade-offs rather than inconsistency in responses.

Statistical Analysis

The choices made by participants (patients and cardiologists) in each scenario were analyzed to obtain the partial utility values of each level of the attributes using a mixed logit regression model for patients. In this model, the participant's choice in each scenario was the dependent variable, while the attribute levels were treated as independent variables. The attributes are the characteristics of the PM (such as battery duration, size, or magnetic resonance imaging [MRI] compatibility), and the levels are the specific options within each attribute (eg, a PM with a battery life of 5 years versus one with 10 years). Unlike conditional logit models, the mixed logit model accounts for preference heterogeneity across individuals, allowing the estimation of preferences at the individual level.^{39,40} However, the mixed logit model did not converge for the cardiologist sample, likely due to the combination of sample size and model complexity. Therefore, a conditional logit model was employed to estimate average preferences for cardiologists. Owing to the use of different model specifications, direct statistical comparison of utility coefficients between patients and cardiologists was not performed. Instead, the

maximum utility values of each attribute were used to establish their relative importance (RI), reflecting the importance of each attribute relative to the others.^{41,42} Statistics of centrality and dispersion were calculated for each RI.

The statistical analysis was performed using STATA v.14. For all statistical tests, a p-value <0.05 was considered significant. Quantitative variables were described using centrality and dispersion statistics (mean, standard deviation [SD], quartiles, minimum and maximum), while qualitative variables were described with relative and absolute frequencies.

Student's *t*-test (or the equivalent non-parametric test in the case of non-normal distribution of the variables) was used to establish the differences in the preferences (RI) assigned by cardiologists and patients.

Compliance with Ethical Guidelines

The study was conducted in accordance with the Declaration of Helsinki and followed International Council for Harmonisation Good Clinical Practice guidelines. The study was evaluated and approved by the Clinical Research Ethics Committee of the Hospital Puerta de Hierro de Madrid, Spain (code 07/23).

All patients provided written informed consent.

Results

Sociodemographic and Clinical Characteristics

A total of 42 patients (66.7% male; mean [SD] age 64.2 [12.1] years; 40.5% with higher education; 73.8% with PM dependency), and 42 cardiologists (64.3% male; mean [SD] age 47.3 [9.3] years; 61.0% working in public healthcare only; mean [SD] 16.8 [9.4] years performing conventional PM implantation and mean [SD] 6.7 [8.1] years performing LLPM; with a mean [SD] of 115 [69.2] PMs implanted last year) met the inclusion criteria, responded correctly to the dominant scenario, and completed the electronic questionnaire (Table 3).

Table 3 Characteristics of Patients and Cardiologists

	Patients	Cardiologists
Sex (%)		
<i>Male</i>	66.7	64.3
<i>Female</i>	33.3	35.7
Mean (SD) years	64.5 (12.1)	47.3 (9.3)
Level of education		
<i>Primary</i>	31.0	–
<i>Secondary</i>	28.6	
<i>Higher</i>	40.5	
PM dependence		
<i>Yes</i>	73.8	–
<i>No</i>	24.2	
Year of PM implantation		
<i>2019-2023</i>	32.4	–
<i>2014-2018</i>	45.9	
<i>Before 2014</i>	21.6	
Professional practice		
<i>Public healthcare</i>	–	61.9
<i>Public and private healthcare</i>		38.1
Mean (SD) years implanting conventional PMs	–	16.8 (9.4)
Mean (SD) years implanting LLPMs	–	6.7 (8.1)
Mean (SD) number of PMs implanted last year	–	115.0 (69.2)

Abbreviations: LLPM, Leadless pacemaker; PM, Pacemaker.

Patients' and Cardiologist' Preferences

Partial Utilities

Partial utilities reflect the importance of an attribute level against a reference level.³⁴ A negative coefficient indicates a lower preference for the level compared to the reference level.

For patients (Table 4), all attributes were statistically significant, except for those involving leads or leadless pacing and self-perception, indicating that they are important when choosing a PM. All partial utilities were negative, so the preferred levels are the reference levels [ref]: small size, duration ≥8 years, LLPM, MRI compatibility, no external perception of the device, possibility of generator replacement by the time elective replacement is indicated, and availability of both types of follow-up (in-office and remote).

Table 4 Patients' and Cardiologists' Partial Utilities (DCE 1 and DCE 2)

DCE 1							
Attribute	Level	Coef.	Std. Err.	p-value	Coef.	Std. Err.	p-value
		Patients			Cardiologists		
Size	Small [ref]	0	–	–	0	–	–
	Large	–0.82	0.19	<0.001	–0.63	0.22	0.005
Longevity (battery life)	≥8 years [ref]	0	–	–	0	–	–
	<8 years	–0.97	0.22	<0.001	–1.94	0.25	<0.001
Lead vs leadless pacing	In the absence of leads [ref]	0	–	–	0	–	–
	By implanting leads	–0.23	0.14	0.096	–0.68	0.23	0.003
MRI compatibility	MRI compatible [ref]	0	–	–	0	–	–
	MRI incompatible	–1.21	0.29	<0.001	–2.04	0.26	<0.001
External self -perception	Non-palpable (intraventricular) [ref]	0	–	–	0	–	–
	Palpable (subcutaneous)	–0.10	0.14	0.453	–0.16	0.22	0.457
Generator replacement	It is replaced by a new generator [ref]	0	–	–	0	–	–
	It is not removed and a new generator is implanted	–0.53	0.19	0.004	–0.98	0.23	<0.001
Follow-up	In-office and remote follow-up options available [ref]	0	–	–	0	–	–
	In-office follow-up only (no remote follow-up)	–0.44	0.14	0.002	–1.72	0.26	<0.001
DCE 2							
Attribute	Level	Coef.	Std. Err.	p-value	Coef.	Std. Err.	p-value
Lead vs leadless pacing	In the absence of leads [ref]	–	–	–	0	–	–
	By implanting leads	–	–	–	–0.55	0.30	0.06
12 months post-implant infection rate	<1.5% [ref]	–	–	–	0	–	–
	≥1.5%	–	–	–	–3.41	0.42	<0.001

(Continued)

Table 4 (Continued).

DCE 2							
Attribute	Level	Coef.	Std. Err.	p-value	Coef.	Std. Err.	p-value
Programming modes	Allows programming of all modes (DDD/R, VDD/R, VVI/R, AAI/R) [ref]	–	–	–	0	–	–
	Allows programming of only 2 modes (VVI/R and VDD/R)	–	–	–	–1.60	0.28	<0.001
CSP	Stimulates the left bundle branch area /His bundle [ref]	–	–	–	0	–	–
	Does not allow stimulation of the left bundle branch area/His bundle	–	–	–	–2.66	0.36	<0.001
Algorithms for minimizing unnecessary right ventricular stimulation	It includes algorithms to minimize unnecessary right ventricular stimulation [ref]	–	–	–	0	–	–
	It does not include algorithms to minimize unnecessary right ventricular stimulation	–	–	–	–1.66	0.34	<0.001
Automatic capture control algorithms	It includes automatic capture control algorithms [ref]	–	–	–	0	–	–
	It does not include automatic capture control algorithms	–	–	–	–1.07	0.34	<0.001
Capability of the programmer to check other PM models	Other pacemaker models [ref]	–	–	–	0	–	–
	Only the implanted pacemaker model	–	–	–	–0.56	0.29	0.05

Note: Values in bold indicate statistically significant differences ($p < 0.05$).

Abbreviations: AAI/R, single chamber atrial stimulation; CSP, conduction system pacing; DDD/R, sequential stimulation with two leads; MRI, magnetic resonance imaging; PM, pacemaker; VDD/R, single-wire sequential stimulation; VVI/R, single chamber ventricular stimulation.

Similarly, for cardiologists (Table 4), all attributes, except for external self-perception, were statistically significant and therefore considered drivers of decision making. Likewise, all utilities were negative, so the preferred levels are reference levels.

The partial utilities showed that all the presented technical characteristics, except for the capability of the programmer to check other PM models and lead vs leadless pacing, were relevant for the decision (Table 4). In this case, the reference levels were also the preferred ones: leadless pacing, 12-month post-implantation infection rate of <1.5%, allows programming of all modes, CSP, inclusion of algorithms to minimize unnecessary right ventricular stimulation, inclusion of automatic capture control algorithms, and the compatibility of the programmer with other PM models.

Relative Importance

The RI assigned to each attribute enables the characteristics of the PM to be ranked and establishes the importance of each attribute compared to the rest.

For both patients (P) and cardiologists (C) (Figure 1), the most relevant characteristics of PMs (higher RI) were MRI compatibility (P: 28.1%; C: 25.1%) and battery longevity (P: 22.6%; C: 23.8%). In third place, cardiologists assigned greater importance to the type of follow-up (21.1%), whereas patients considered PM size a more valuable characteristic (P: 19.1%). Finally, leadless pacing and external self-perception were the least prioritized characteristics by both doctors and patients (P: 2.4%; C: 2.0%).

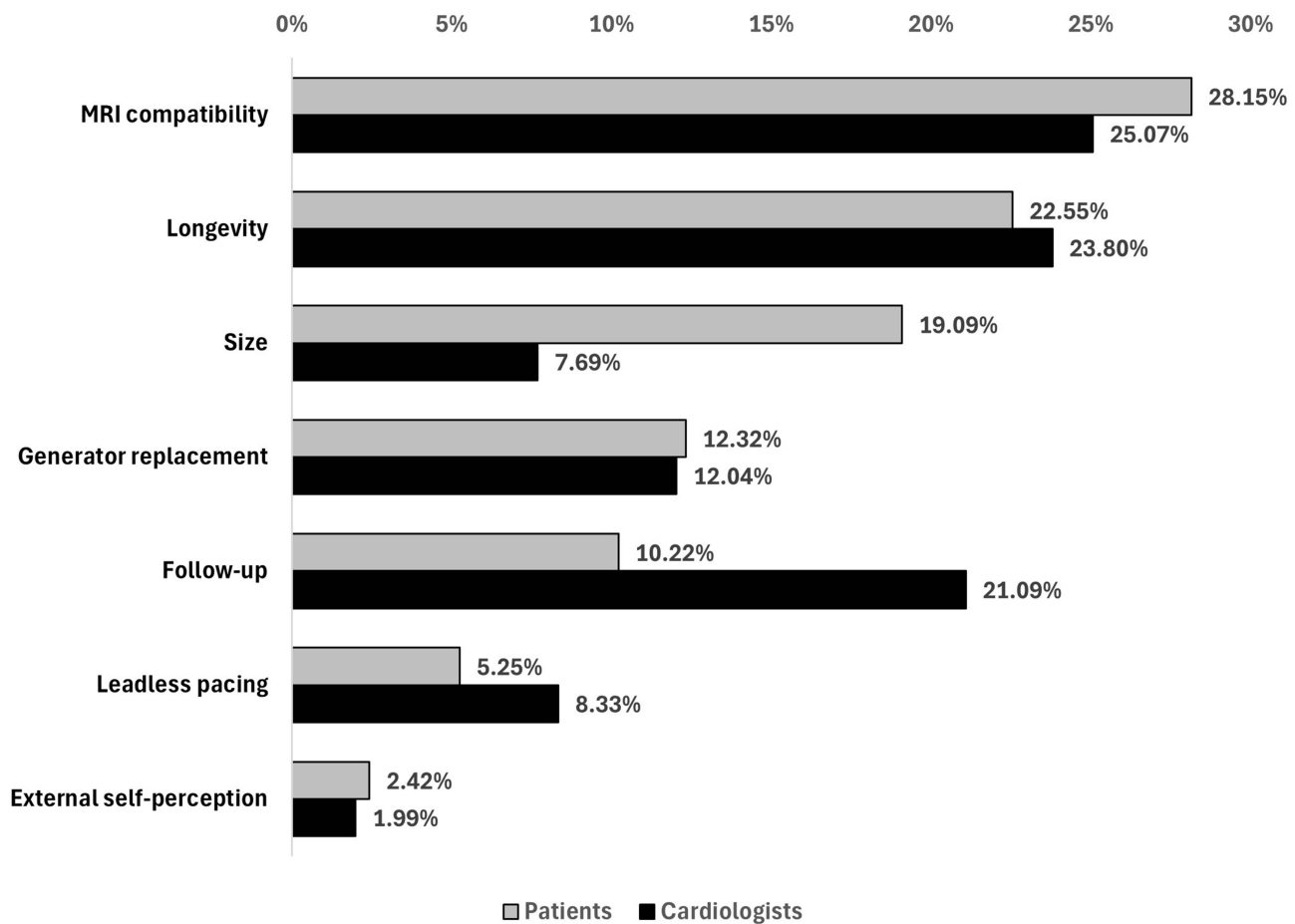


Figure 1 Relative importance given by patients and cardiologists (DCEI).

When all the characteristics of the PMs were considered (including those technical features of DCE 2), the most important and therefore decision drivers from the cardiologists' perspective were: 12-month post-implantation infection rate (19.39%), CSP (15.14%), MRI compatibility (9.44%), algorithms for minimizing unnecessary right ventricular stimulation (9.43%), programming modes (9.11%), and battery longevity (8.96%) (Figure 2).

Discussion

Current guidelines for the management of patients with cardiovascular diseases recommend that clinicians should engage eligible patients in shared decision-making,^{29,30} particularly when it comes to selecting the type of stimulation (pacing or resynchronization), programming type, and addressing patient needs during cardiac device placement.³⁰ A key component of patient-centered care is involving patients in decision-making, which ensures that treatment decisions align with patients' values and needs.²⁶ Therefore, understanding their preferences is crucial for the successful implementation of this approach.

This study provides information on the preferences of patients and cardiologists for PM characteristics. This preference data may facilitate shared decision-making, since most of the attributes included in DCEs significantly predicted choice and were important to this process. Additionally, the information gathered in this study could be highly useful in defining the clinical development strategy of new devices, potentially helping to create devices that reflect the preferences of both patients and cardiologists.

A total of 42 patients and 42 cardiologists participated in the study. The characteristics of the patient sample were broadly comparable to those reported in the 2023 National Pacemaker Registry published by the Heart Rhythm Association of the Spanish Society of Cardiology.⁹ However, patients included in our study were substantially younger (64.5 vs 77.8 years) than those reported in the registry.⁹ This age difference likely reflects a selection effect inherent to

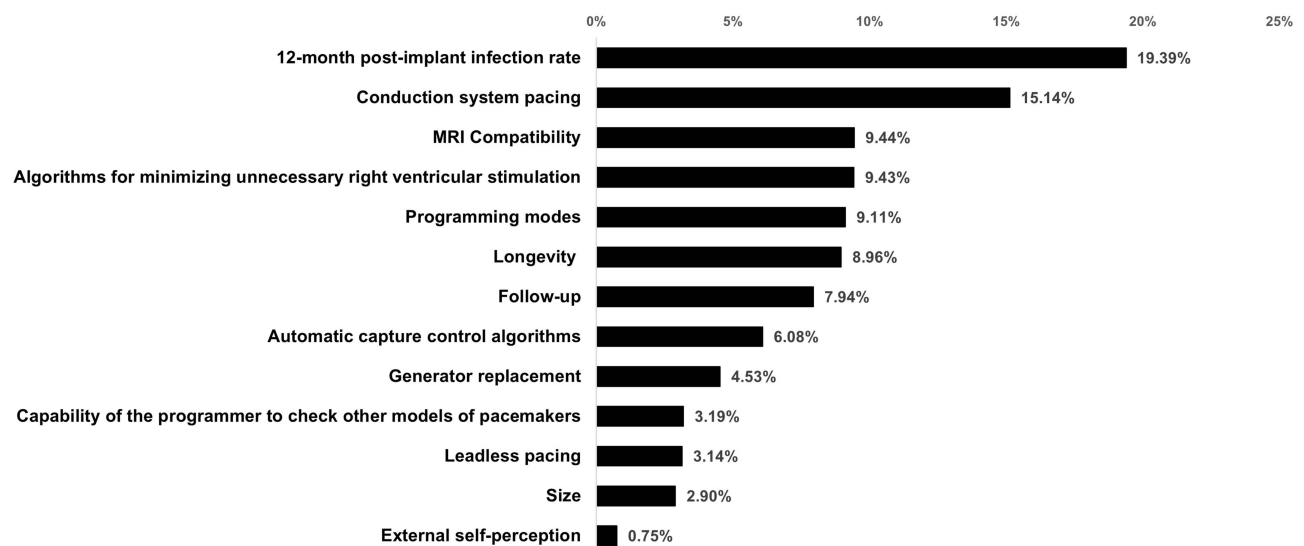


Figure 2 Relative importance of cardiologists (DCE2).

preference-based studies using self-administered electronic questionnaires and cognitively demanding DCE, which may limit participation among older or more frail patients. This limitation may affect the generalizability of the findings but does not compromise the internal validity of the estimated preference structures. In contrast, the data show that the cardiologists involved have extensive experience in PM implantation and follow-up.

Although different surveys have explored patient preferences on topics related to cardiac implantable electronic devices (such as discharge timing after implantation,⁴³ their experiences with PM home follow-up,^{44,45} preferences for PM removal,^{46,47} and removable over non-removable LLPMS and conventional PMs⁴⁸), no prior studies have examined the perspective of both patients and cardiologists on the specific elements of PMs. To our knowledge, this is the first study evaluating the preferences of both patients and cardiologists for PM characteristics.

The study results show that, for both groups, MRI compatibility and longer longevity of the PMs (≥ 8 years) are the main decision drivers.

MRI is considered the gold standard imaging technique for a wide range of cardiac and non-cardiac diseases, and it is estimated that about 50%-75% of patients with PMs will need an MRI during their lifetime. While having a PM was previously considered an absolute contraindication for MRI, significant advances in PM device technology have made it possible to overcome this challenge.⁴⁹⁻⁵¹

Regarding battery longevity, a recent systematic review⁵² showed that one of the most common complications in patients with a PM was early battery depletion (a battery that fails before the manufacturer's specified lifespan), which affected between 0.8%⁵³ to 5.5%⁵⁴ of patients. However, the improvements made to PMs have enhanced performance in this regard. A recent study has reported that real-world data on longevity exceeds manufacturer predictions, with a median virtual battery life reaching up to 16 years.⁵⁵

The type of follow-up is also an aspect valued by both cardiologists and patients. Previous evidence from semi-structured interviews with patients and clinicians shows that, although there are concerns about the limited understanding of how remote follow-up and alerts work, patients and clinicians generally have confidence in the technology and remote monitoring.⁴⁴ Furthermore, in line with our findings, a patient survey indicated that patients prefer remote follow-up, citing benefits such as reduced travel time and receiving actionable alerts.⁴⁵ Remote monitoring has also been shown to reduce hospitalizations and healthcare resource use,⁵⁶⁻⁵⁹ and to provide clinical benefits, including longer battery life and better survival rates.^{56,60}

From the patients' perspective, the size of the PM is also a decision driver. Reducing the generator size has been one of the key goals pursued in advancing PM technology.⁶¹ Over the years, smaller PMs have been developed to offer several benefits, including improved patient comfort, reduced risk of complications, and easier implantation, especially in patients with smaller or more challenging anatomies.⁶¹

Analysis of cardiologists' preferences for technical characteristics (DCE 2) showed that cardiologists assigned the highest RI to infections at 12 months post-implantation, followed by CSP, MRI compatibility, and algorithms for minimization of right ventricular stimulation. The higher preference for fewer infections is further supported by the established association between infections and increased morbidity and mortality.⁶²

The risk of infection may be influenced by several elements, including technical factors (generator size, number of interventions), patient factors (comorbidities like diabetes mellitus, heart failure, chronic kidney disease, and other transient conditions), periprocedural factors, and the implantation approach.^{63–65} LLPMs have a lower infection rate than conventional PMs, mainly due to the absence of a subcutaneous pocket and leads and reduced skin and glove contact, as well as differences in size, external self-perception, and device material.⁶⁵

These preferences are consistent with current trends in pacing strategies, which increasingly favor dual-chamber systems and physiologic pacing approaches. Recent evidence indicates that dual-chamber pacing is associated with improved myocardial performance and better clinical outcomes compared with single-chamber pacing, and that conduction system pacing, including left bundle branch pacing, provides significant clinical and long term benefits and is increasingly considered part of standard of care.^{66,67}

Cardiologists' preferences for CSP aligns with its proven general feasibility and safety,^{68–74} along with its advantages such as reduced interventricular dyssynchrony, preventing PM-induced cardiomyopathy,⁷⁵ and its safety in patients with cardiac amyloidosis.⁷⁶ Algorithms to minimize right ventricular pacing can reduce the risk of permanent atrial fibrillation and cardiovascular hospitalization in patients requiring anti-bradycardia therapies, without an increased risk of adverse symptoms.⁷⁷ Different algorithms, such as the Ventricular Pace Suppression algorithm and the Intrinsic Rhythm Support plus algorithm, have proven to be safe and effective in reducing unnecessary ventricular pacing in patients with symptomatic sinus node dysfunction.⁷⁸ These considerations support the significant value placed by cardiologists on the algorithms to reduce unnecessary right ventricular pacing.

Our findings are partially consistent with previous preference studies,⁴⁸ evaluating patient preferences for features associated with leadless versus conventional transvenous pacemakers. While prior studies have highlighted the relevance of leadless systems from the patient perspective, particularly in relation to perceived safety and comfort, our results suggest that both patients and cardiologists place greater emphasis on specific device outcomes and characteristics—such as MRI compatibility, battery longevity, and infection risk—rather than on device type alone. Differences across studies may be related to variations in study design, healthcare setting, and population characteristics. Nevertheless, the consistent prioritization of safety- and outcome-related attributes across studies suggests the presence of common perceptions that transcend individual healthcare systems.

Importantly, although leadless pacemakers are associated with lower infection rates,⁷⁹ cardiologists did not prioritize the device type (leadless vs conventional) as an isolated attribute. This finding likely reflects the fact that clinicians prioritize infection risk as a clinical outcome rather than as a surrogate for a specific device category. In routine practice, infection risk is multifactorial and influenced not only by lead presence, but also by patient comorbidities, implantation technique, procedural volume, and follow-up strategies. Consequently, cardiologists may focus on minimizing infection risk regardless of the pacing technology used, which may explain this apparent discrepancy.

Additionally, having access to all programming modes could be highly beneficial for patients in specific situations, such as during cardiac rehabilitation programs involving physical exercise. For example, the rate responsive function (RRF) of the PM programming mode plays a crucial role in patients' exercise capacity, as patients with RRF activated demonstrated superior functional capacity.⁸⁰

Study Limitations

This study has limitations, some of which are inherent to its design. Although the DCE is the recommended method for assessing the preferences of patients and healthcare professionals for the characteristics of a treatment or medical device, there is always a risk of a mismatch between the stated and revealed preferences,^{34,81} and therefore the choices made by patients or cardiologists in real life may differ from those made in the DCE. Furthermore, although the use of self-administered electronic questionnaires ensures that the sample number required to respond to the main study objective is reached, the accuracy of the data provided by the participants cannot be verified.⁸² In addition, this methodology has an inherent selection bias caused by

the fact that the answers will only be provided by those patients and cardiologists willing to participate in the study, whose opinions could differ from those who refuse to participate.⁸² Limitations may also arise in the selection of attributes and/or levels; the DCE may not include potentially relevant attributes, or the selection of levels within an attribute may not be appropriate. To minimize this potential bias, the SC members and patient focus group reviewed and verified the relevance of the attributes and levels included in the DCE. Finally, this study was conducted exclusively in Spain within the context of the Spanish public healthcare system. As healthcare organization, clinical practice patterns, and cultural factors may influence preferences, the generalizability of these findings to other countries and healthcare settings may be limited.

Conclusion

The information provided by this study enables the identification and quantification of patients' and cardiologists' preferences for the characteristics of PMs. For both groups, MRI compatibility and battery longevity emerged as key drivers in the decision-making process. Additionally, patients attach relevance to other aspects such as the generator size and its replacement process. In contrast, cardiologists place significant importance on aspects related to the type of follow-up and other safety and technical considerations such as the 12-month post-implantation infection rate, conduction system pacing, and algorithms to reduce unnecessary ventricular stimulation.

Considering the broad range of PMs currently available, information on patients' and cardiologists' preferences may promote and facilitate shared decision-making. Moreover, this knowledge may guide the development of new devices that reflect these preferences, ensuring that innovations meet the needs and expectations of both patients and cardiologists.

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