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¹ Boehmer JP, Hariharan R, Devecchi FG, et al. A Multisensor algorithm predicts heart failure events in patients with implanted devices: results from the MultiSENSE study. JACC Heart Fail. 2017 Mar;5(3):216-25. CRM-572611-AA

Healthcare utilization in patients with first-time implantable cardioverter defibrillators (data from the WEBCARE study)

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Abstract

Background: Knowledge of the level of healthcare utilization (HCU) and the predictors of high HCU use in patients with an implantable cardioverter defibrillator (ICD) is lacking. We examined the level of HCU and predictors associated with increased HCU in first-time ICD patients, using a prospective study design.

Methods: ICD patients (N = 201) completed a set of questionnaires at baseline and 3, 6, and 12 months after inclusion. A hierarchical multiple linear regression with three models was performed to examine predictors of HCU.

Results: HCU was highest between baseline and 3 months postimplantation and gradually decreased during 12 months follow-up. During the first year postimplantation, only depression ($\beta = 0.342$, $P = 0.002$) was a significant predictor. Between baseline and 3 months follow-up, younger age ($\beta = -0.220$, $P < 0.01$), New York Heart Association class III/IV ($\beta = 0.705$, $P = 0.01$), and secondary indication ($\beta = 0.148$, $P = 0.05$) were independent predictors for increased HCU. Between 3 and 6 months follow-up, younger age ($\beta = -0.151$, $P = 0.05$) and depression ($\beta = 0.370$, $P < 0.001$) predicted increased HCU. Between 6 and 12 months only depression ($\beta = 0.355$, $P = 0.001$) remained a significant predictor.

Conclusions: Depression was an important predictor of increased HCU in ICD patients in the first year postimplantation, particularly after 3 months postimplantation. Identifying patients who need additional care and provide this on time might better meet patients' needs and lower future HCU.

KEYWORDS

depression, healthcare utilization, implantable cardioverter defibrillator, mental health

1 | INTRODUCTION

The implantable cardioverter defibrillator (ICD) is the treatment of choice for the prevention of potentially life-threatening cardiac tachyarrhythmias in high-risk patients (primary prevention) and in patients who have experienced cardiac tachyarrhythmias in the past (secondary prevention).¹ The ICD constantly monitors the heart rate and in case of a ventricular tachyarrhythmia delivers a shock in order to restore

a normal rhythm.² Because of the proven benefits of the ICD as compared to antiarrhythmic medication terminating tachyarrhythmias,³ the number of ICD implants has increased over the past years, although a plateau now has been reached in at least many European countries.⁴

Besides the unequivocal medical benefits, ICD therapy is associated with a risk of complications and increased healthcare costs have been reported.⁵ Receiving an ICD is associated with high

healthcare costs as the implantation device itself can be as expensive as 30 000 euros.⁶ In addition, after implantation, patients are generally followed-up at 1-to-4-month intervals (depending on patients' clinical status and device model) at the outpatient clinic.² These follow-ups are generally performed by the ICD technicians but may also involve a consult by the cardiologist in case of complications (eg, wound infections, lead failure), which may result in even higher healthcare expenses.⁵ Besides patients' medical needs with respect to living with an ICD, a significant subgroup (1 in 5) reports symptoms of anxiety and depression at a level that warrants treatment⁷ and that affects patients' physical and mental functioning.⁸ In turn, this may lead to a further increase in healthcare utilization (HCU) and associated costs.

Previous studies have shown that an increase of HCU depends on patients' demographic, medical, and psychological characteristics (eg, multimorbidity, mental health disorders).⁹ As some of these factors are modifiable, it is important to timely identify this subset of patients at the time of implantation and to provide patients with relevant care in order to reduce HCU and associated costs. To the best of our knowledge, no studies to date have examined the level of HCU and its predictors in the ICD population. Hence, in the current study we examined the level of HCU and the predictors of increased HCU and costs in patients with an ICD.

2 | METHODS

2.1 | Participants and study procedure

Data for the current study have been collected as part of the WEB-based distress management program for implantable CARDioverter dEfibrillator patients (WEBCARE), which was a multicenter randomized controlled trial.¹⁰ The study sample consisted of patients who were admitted for a first-time implantation of an ICD. Patients were recruited between April 2010 and February 2013 from six Dutch referral hospitals (Amphia Hospital, Breda; Canisius-Wilhelmina Hospital, Nijmegen; Catharina Hospital, Eindhoven; Erasmus Medical Centre, Rotterdam; Onze Lieve Vrouwe Gasthuis, Amsterdam; Vlietland Hospital, Schiedam).

The ICD technician or ICD nurse of the participating hospitals approached all patients between 18 and 75 years who received a first-time ICD implant for participation. Exclusion criteria were a history of psychiatric illness other than depressive or anxiety disorders, significant cognitive impairments (eg, dementia), being on the waiting list for heart transplantation, life-threatening comorbidities (eg, malignancies), life expectancy less than 1 year, lack of internet/computer skills, and insufficient knowledge of the Dutch language. In the 1-year follow-up period after the ICD implantation, patients were requested to complete a set of validated and standardized questionnaires at four time-points (baseline, 3, 6, and 12 months after inclusion). The study procedure has been described elsewhere in more detail.¹⁰ The study protocol was approved by the Medical Ethical Committees of all participating centers and the study was conducted in accordance to the Helsinki declaration.

2.2 | Demographic and clinical variables

Information on demographic (age, gender, educational level) and clinical variables (Charlson Comorbidity Index [CCI], New York Heart Association [NYHA] functional class [NYHA-class I/II vs III/IV], ICD indication [primary vs secondary indication], and total shocks [appropriate and inappropriate]) was obtained from purpose-designed questions in the questionnaires and patients' medical records.

2.3 | Healthcare utilization

An adjusted version of the Trimbos/iMTA questionnaire for Costs associated with Psychiatric Illness (TiC-P) was used to assess HCU in the WEBCARE population.¹¹ This generic patient self-report survey includes 14 structured yes/no questions on relevant medical resources (eg, "Did you consult with a General Practitioner at any time during the past three months").¹¹ Each item is followed by a question on the frequency of utilization of that specific medical resource over the past 3 months. For example, the baseline score represents the HCU within the 3 months prior to ICD implantation, while the 3-month score reflects HCU between baseline and 3 months postimplantation. For the current study, only the items referring to medical resource use (eg, General Practitioner, company doctor, physiotherapist, and outpatient hospital visits) were used, whereas current sample is not a psychiatric population and psychological HCU was reported sporadically. The reliability and validity of the medical resource items are considered satisfactory (Cohen's kappa ranges from 0.597 to 0.795) within the population of patients with mild to moderate mental health problems,¹¹ and is previously used within the cardiac population.¹²

2.4 | Anxiety

Symptoms of anxiety were assessed with the 7-item General Anxiety Disorder scale (GAD-7). The GAD-7 items (eg, "Feeling afraid, as if something awful might happen") are rated on a 4-point Likert scale ranging from 0 (not at all) to 3 (almost every day).¹³ The total score implies severity of anxiety and ranges from 0 to 21, with higher scores indicating higher anxiety levels. With a Cronbach's alpha of 0.92, the internal consistency of the GAD-7 is considered excellent.¹³

2.5 | Depression

Depressive symptoms were assessed with the Patient Health Questionnaire (PHQ-9), a patient self-report survey which is comprised of 9 items (eg, "Feeling down, depressed, or hopeless") that are answered on a 4-point Likert scale ranging from 0 (not at all) to 3 (nearly every day).¹⁴ The score range is between 0 and 27, with higher scores representing a higher level of depression symptom severity. The internal consistency is considered excellent, with Cronbach's alpha of 0.90.¹⁴

2.6 | Type D personality

Type D (distressed) personality was assessed with the DS14 (Type D scale).¹⁵ This questionnaire consists of 14 items with two 7-item

subscales measuring Social Inhibition (eg, “I find it hard to start a conversation”) and Negative Affectivity (eg, “I am often in a bad mood”).¹⁵ The items are rated on a 5-point Likert scale from 0 (false) to 4 (true). The total score of both subscales range from 0 to 28. Patients are classified as Type D when scoring ≥ 10 on both subscales. The internal consistency of SI and NA are considered satisfactory, with reported Cronbach's alphas of 0.86 and 0.88, respectively.¹⁵

2.7 | Statistical analysis

Descriptive statistics of the baseline variables were evaluated using frequencies (categorical variables) and mean scores with standard deviations (SD) (continuous variables). They are presented as percentages and means \pm SDs, respectively. Differences between nonresponders and participants on baseline characteristics were calculated by using the χ^2 test for independence (categorical variables) and independent sample t-tests (continuous variables). Missing data were handled by using pairwise deletion (available-case analysis). In order to assess whether a priori determined demographic characteristics (age, gender, and education), clinical variables (NYHA class, ICD indication, total shocks [appropriate and inappropriate], CCI), and psychological variables (anxiety, depression, and Type D personality) were associated with total HCU in ICD patients the first year after implantation, a sum score was calculated for the number of healthcare use during the 12-month period. Baseline measurement for the sum score was excluded, as this score reflects HCU before the ICD implantation. Generalized linear modelling was used to investigate the change in HCU over time. As HCU is considered count data, a Poisson distribution with log linear link function was used to model HCU scores over time. Time was modelled as a continuous variable because the intervals between the measurements were unequally spaced. A hierarchical multivariable regression with three models was performed in order to examine the predictors of HCU. Demographic characteristics were entered in the *first model*. In the second model, clinical variables were entered, followed by the psychological variables in the third model. Subsequently, more detailed information about the course of HCU over the year was provided by performing the same analyses for time-point specific reported HCU at 3 (reflecting HCU between baseline and 3 months follow-up), 6 (reflecting HCU between 3 and 6 months follow-up), and 12 months (reflecting HCU between 9 and 12 months follow-up) after ICD implantation, respectively. All analyses were conducted using IBM SPSS Statistics 22.0 (IBM Corp., Armonk, NY, USA). A *P* value < 0.05 was considered statistically significant.

3 | RESULTS

3.1 | Patient characteristics

A total of 1024 patients were approached for participation, with 562 patients being eligible and 340 patients signing the informed consent. Of these 340 patients, 15% (51/340) did not return the baseline questionnaire, an additional 11% (31/289) were lost to

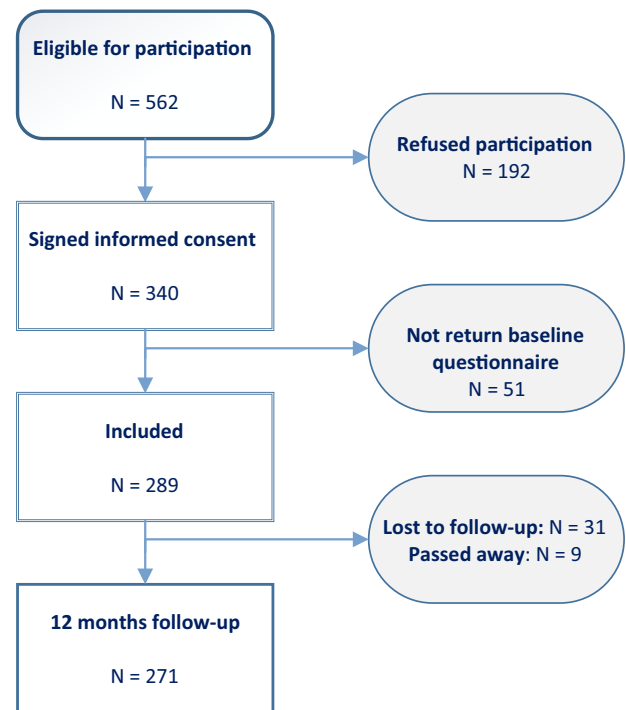


FIGURE 1 Flowchart of patient recruitment [Color figure can be viewed at wileyonlinelibrary.com]

follow-up, and 3% (9/280) passed away in the period between baseline and 12 months follow-up (see Figure 1 for a detailed description of the sample selection). A total of 201 patients was included in the current analyses. The majority of the patients were men (274/340; 80.6%), with a mean age of 58 ± 10 years. Nonresponders, compared to participants, were more likely to have a NYHA functional class III/IV (58.1% vs 18.9%; χ^2 (1, 221) = 30.88, $P < 0.001$, $\phi = -0.39$), more likely to be diagnosed with diabetes mellitus (35.5% vs 14.0%; χ^2 (1, 262) = 12.79, $P < 0.001$, $\phi = -0.23$), and more likely to have peripheral vascular disease (12.9% vs 4.5%; χ^2 (1, 262) = 4.21, $P = 0.040$, $\phi = -0.15$). A detailed overview of the baseline sample characteristics is presented in Table 1.

3.2 | Healthcare utilization

The mean frequency of HCU (number of visits to General Practitioner, company doctor, physiotherapist, and outpatient hospital visits), within the first year following the ICD implantation, was 6.20 three months after implantation (0 to 3 months), 5.36 at 6 months follow-up (3 to 6 months), and 4.76 12 months postimplantation (9 to 12 months), respectively (Table 2). These HCU frequencies did not significantly differ across time (F (2, 680) = 2.738, $P = 0.065$).

3.3 | Predictors of total HCU within 12 months postimplantation

Assessing the predictors of total HCU within 12 months post-ICD implantation, analyses showed that sociodemographic variables (Model 1) did not explain a significant part of the variance in HCU (F (3, 155) = 0.91, $P = 0.437$, $\Delta R^2 = 0.017$). However, after adding

TABLE 1 Baseline patient characteristics of the total sample

Variable	Mean \pm SD; N (%)
Demographic	
Age	58.16 \pm 10.30
Gender (men)	274 (80.6)
Partner (yes) ^{N = 288}	244 (71.8)
Education level (High) ^{N = 288}	208 (61.2)
Work (yes) ^{N = 288}	141 (41.5)
Clinical	
Heart failure (yes) ^{N = 339}	181 (53.2)
NYHA class III/IV ^{N = 267}	57 (21.3)
Ischemic heart disease (yes) ^{N = 339}	204 (60.0)
Atrial fibrillation (yes) ^{N = 339}	80 (23.5)
Secondary prevention indication ^{N = 339}	47 (13.8)
Any shocks ^a	28 (8.2)
Anemia (yes) ^{N = 339}	17 (5.0)
CVA in past ^{N = 339}	15 (4.4)
TIA in past ^{N = 339}	26 (7.6)
PAD ^{N = 339}	18 (5.3)
COPD (yes) ^{N = 339}	26 (7.6)
Diabetes mellitus (yes) ^{N = 339}	51 (15.0)
Dyslipidemia (yes) ^{N = 339}	71 (20.9)
Hypertension (yes) ^{N = 339}	76 (22.4)
Malignancy, excluding metastatic cancer ^{N = 339}	14 (4.1)
Psychological	
Anxiety (GAD-7) ^{N = 288}	4.30 \pm 4.54
Depression (PHQ-9) ^{N = 289}	5.45 \pm 4.83
Type D personality (yes) ^{N = 288}	45 (13.2)
Cardiac medication	
Psychotropics ^{N = 339}	33 (9.7)
ACE-inhibitors ^{N = 339}	206 (60.6)
Beta-blockers ^{N = 339}	279 (82.1)
Statins ^{N = 339}	209 (61.5)
Diuretics ^{N = 339}	172 (50.6)
Amiodarone ^{N = 339}	31 (9.1)

ACE = angiotensin-converting enzyme; COPD = chronic obstructive pulmonary disease; CVA = cerebrovascular accident; GAD-7 = 7-item General Anxiety Disorder scale; NYHA = New York Heart Association; PAD = peripheral arterial disease; PHQ-9 = Patient Health Questionnaire; TIA = transient ischemic attack.

^aShocks received between implantation and 12 months.

TABLE 2 Overview of healthcare utilization over 12 months post-ICD implantation

Measurement point	Mean \pm SD
HCU Baseline	5.39 \pm 5.92
HCU 3 months after implantation	6.20 \pm 7.89
HCU 6 months after implantation	5.36 \pm 7.34
HCU 12 months after implantation	4.76 \pm 7.38

HCU = healthcare utilization; ICD = implantable cardioverter defibrillator; SD = standard deviation.

clinical characteristics (Model 2), the regression model improved significantly ($F(4, 151) = 2.02, P = 0.027, \Delta R^2 = 0.068$) and explained 9% of the total variance in HCU. Age ($\beta = -0.187, P = 0.029$), NYHA class ($\beta = 0.179, P = 0.026$), and CCI ($\beta = 0.176, P = 0.034$) emerged as independent predictors of postimplantation HCU. With the addition of psychological variables (Model 3), 15% of the variance in HCU was explained ($F(3, 148) = 2.67, P = 0.010, \Delta R^2 = 0.067$), adding to the level of prediction of the model. Of all the predictors in the final model, only depression appeared to be significantly associated with total HCU ($\beta = 0.342, P = 0.002$). This association indicates that higher depression scores at baseline are associated with higher HCU the first year postimplantation, independent of demographic, clinical, and psychological variables (see Table 3 for a detailed overview of the regression model).

3.4 | HCU at 3, 6, and 12 months

3.4.1 | Baseline–3 months follow-up

Assessing the predictors of HCU within the first 3 months post-ICD implantation revealed that sociodemographic characteristics were not associated with HCU (Model 1: $F(3, 177) = 1.91, P = 0.130, \Delta R^2 = 0.031$). In Model 2, clinical characteristics were added to the sociodemographic characteristics and this model explained 10% of the total variance in HCU ($F(4, 173) = 2.65, P = 0.016, \Delta R^2 = 0.066$). Younger age ($\beta = -0.220, P = 0.006$), NYHA class III/IV ($\beta = 0.188, P = 0.012$), and secondary indication for ICD ($\beta = 0.148, P = 0.045$) were independent predictors in this model. Adding anxiety, depression, and Type D personality in Model 3 did not significantly increase the explained variance in HCU ($F(3, 170) = 2.15, P = 0.406, \Delta R^2 = 0.015$). Younger age ($\beta = -0.226, P = 0.005$), NYHA class III/IV ($\beta = 0.163, P = 0.035$), and secondary indication for an ICD ($\beta = 0.145, P = 0.049$) remained significant predictors of HCU. See Table 3 for a detailed overview.

3.4.2 | Three to 6 months follow-up

For HCU between 3 and 6 months postimplantation, demographic variables (Model 1) did not explain a significant proportion of the variance ($F(3, 184) = 1.34, P = 0.263, \Delta R^2 = 0.021$). When adding clinical characteristics in Model 2, the model did not explain a significant proportion of the variance ($F(4, 180) = 1.96, P = 0.052, \Delta R^2 = 0.049$). Younger age ($\beta = -0.177, P = 0.024$) and CCI ($\beta = 0.157, P = 0.039$) were significantly associated with HCU. Sociodemographic, clinical, and psychological characteristics combined in Model 3 accounted for a significant 15% of the variance in HCU ($F(3, 177) = 3.04, P = 0.002, \Delta R^2 = 0.076$). In this model, younger age ($\beta = -0.151, P = 0.050$) and depression ($\beta = 0.370, P < 0.001$) were associated with increased HCU, independent of other demographic, clinical, and psychological variables (see Table 3).

3.4.3 | Six to 12 months follow-up

Between 6 and 12 months, sociodemographic characteristics in Model 1 were not associated with HCU ($F(3, 170) = 0.72, P = 0.544, \Delta R^2 = 0.012$). Addition of clinical characteristics in Model 2 did not

TABLE 3 Predictors of HCU over the entire 12 months, at 3, 6, and 12 months after ICD implantation

	Total			3 months			6 months			12 months		
	B	SE B	B	B	SE B	β	B	SE B	β	B	SE B	β
Model 1:												
Age	-0.241	0.156	-0.129	-0.135	0.059	-0.177*	-0.091	0.054	-0.128	0.023	0.057	0.032
Gender ^a	0.596	4.001	0.012	-0.702	1.525	-0.035	-0.930	1.398	-0.050	1.858	1.469	0.100
Education ^b	-1.380	3.494	-0.032	0.428	1.332	0.024	-1.641	1.221	-0.099	1.037	1.283	0.063
Model 2:												
Age	-0.348	0.158	-0.187*	-0.169	0.060	-0.220**	-0.126	0.056	-0.177*	-0.007	0.059	-0.009
Gender	0.405	4.002	0.008	-0.779	1.524	-0.039	-0.989	1.410	-0.053	2.054	1.502	0.110
Education	-0.540	3.432	-0.012	0.689	1.307	0.039	-1.363	1.209	-0.083	1.300	1.288	0.078
CCI	3.611	1.683	0.176*	1.055	0.641	0.125	1.235	0.593	0.157*	1.302	0.632	0.165
NYHA class	8.385	3.741	0.179*	3.607	1.424	0.188*	2.512	1.318	0.140	0.128	1.404	0.007
ICD indication ^c	2.389	1.851	0.102	1.421	0.705	0.148*	0.803	0.652	0.090	-0.115	0.695	-0.013
Total shocks ^d	-0.180	2.712	-0.005	-0.030	1.033	-0.002	-0.340	0.955	-0.026	0.076	1.018	0.006
Model 3:												
Age	-0.306	0.156	-0.164	-0.173	0.061	-0.226**	-0.107	0.054	-0.151*	0.019	0.058	0.026
Gender	-1.650	3.960	-0.034	-0.882	1.551	-0.044	-1.851	1.387	-0.100	1.088	1.479	0.058
Education	-0.760	3.358	-0.018	0.499	1.316	0.028	-1.430	1.176	-0.087	1.339	1.254	0.081
CCI	3.277	1.683	0.159	1.160	0.659	0.137	1.056	0.589	0.135	1.068	0.629	0.135
NYHA class	5.652	3.760	0.121	3.127	1.473	0.163*	1.391	1.317	0.078	-0.866	1.404	-0.048
ICD indication	2.379	1.801	0.101	1.399	0.706	0.145*	0.799	0.631	0.089	-0.100	0.673	-0.011
Total shocks	-0.446	2.642	-0.013	-0.071	1.035	-0.005	-0.459	0.925	-0.035	-0.018	0.987	-0.100
Anxiety ^e	-0.621	0.441	-0.146	-0.196	0.173	-0.112	-0.254	0.155	-0.157	-0.148	0.165	-0.091
Depression ^f	1.362	0.422	0.342*	0.186	0.166	0.114	0.561	0.148	0.370**	0.542	0.158	0.355**
Type D personality ^g	-6.795	4.347	-0.128	-1.833	1.703	-0.084	-2.301	1.522	-0.114	-2.317	1.623	-0.114

^aMale vs female.

^bHigh vs low level.

^cSecondary vs primary indication.

^dtotal shocks (both appropriate and inappropriate) received between implantation and 12 months

^eContinuous.

^fContinuous.

^gType D personality vs non-Type D personality.

Total: $R^2 = 0.02$ for model 1, $\Delta R^2 = 0.07$ ($P = 0.03$) for model 2, $\Delta R^2 = 0.07$ ($P = 0.01$) for model 3.

3 months: $R^2 = 0.03$ for model 1, $\Delta R^2 = 0.07$ ($P = 0.02$) for model 2, $\Delta R^2 = 0.02$ ($P = 0.41$) for model 3.

6 months: $R^2 = 0.02$ for model 1, $\Delta R^2 = 0.07$ ($P = 0.05$) for model 2, $\Delta R^2 = 0.08$ ($P < 0.01$) for model 3.

12 months: $R^2 = 0.01$ for model 1, $\Delta R^2 = 0.03$ ($P = 0.36$) for model 2, $\Delta R^2 = 0.08$ ($P < 0.01$) for model 3.

^h* $P \leq 0.05$.

ⁱ** $P \leq 0.01$.

CCI = Charlson Comorbidity Index (continuous); HCU = healthcare utilization; ICD = implantable cardioverter defibrillator; NYHA class = New York Heart Association functional class (III-IV vs I-II).

significantly improve the level of prediction of the model ($F(4, 166) = 0.94, P = 0.358, \Delta R^2 = 0.026$). When combining sociodemographic, clinical, and psychological characteristics in Model 3, a significant 12% of the variance in HCU was explained ($F(3, 163) = 2.13, P = 0.003, \Delta R^2 = 0.078$). Depression ($\beta = 0.355, P = 0.001$) was the only variable associated with increased HCU independent of demographic, clinical, and psychological variables (see Table 3).

Although the influence of depression on HCU was larger at 6 and 12 months than at 3 months, these differences failed to reach significance.

4 | DISCUSSION

To our knowledge, this is the first study to tap into HCU and its predictors in patients with an ICD. The results of the current study showed that HCU was the highest between baseline and 3 months postimplantation and that it gradually decreased over the 12-months follow-up. Focusing on the predictors of HCU, the results showed that for total HCU in the first year postimplantation only depression was a significant predictor after controlling for demographic and clinical variables. When focusing on HCU within the first 12 months postimplantation, analyses showed that between baseline and 3 months postimplantation, younger age, NYHA class, and secondary indication were associated with increased HCU, adjusting for baseline demographic and clinical and psychological characteristics. However, between 3 and 6 months postimplantation only younger age and depression were significant predictors of HCU after controlling for other relevant variables. In addition, between 6 and 12 months only depression was significantly associated with increased HCU independent of other relevant variables.

The current findings are in line with some previous studies in the general cardiac population that focused on HCU. For example, in patients with chronic stable angina, depression was an independent predictor of an increase in mean cumulative 1-year healthcare costs, with a 33% increase in patients with depression as compared to non-depressed patients.¹⁶ This increase was observed in several healthcare sectors after controlling for other healthcare expenditure costs (eg, physician costs, outpatient care, chronic care, inpatient care, and medications).¹⁶ A possible mechanism underlying the association between depression and HCU is the association between depression and unhealthy lifestyle behaviors (eg, smoking, reduced exercise, unhealthy diet, alcohol consumption, and sedentary lifestyle), as depression is a known barrier for lifestyle changes, which may result in poor physical health and eventually in increased HCU.¹⁷ In addition, patients with depression may experience associated somatic symptoms (eg, headaches, sleep disturbances) for which additional care is sought. Another explanation could be that depressed cardiac patients obtain lower quality of care as compared to cardiac patients who are not depressed.¹⁸ This may lead to undertreatment of these patients, resulting in more physical complaints as a consequence. Remarkably, in contrast with existing literature on the relation between anxiety and high HCU in both cardiac and noncardiac populations,^{19,20} the current study did not find this association. The relatively healthy recruited population could possibly explain this. Furthermore, the majority of

patients in the current sample received beta-blockers as part of their cardiac medication regimen.²¹ As beta-blockers are known for their anxiolytic properties,²² this may have further reduced anxiety levels. Speculatively, one might also reason that increased anxiety levels might lead to less medical resource seeking as part of an avoidant coping strategy.

Within the ICD population specifically, appropriate and inappropriate shocks are well known predictors of HCU.^{23,24} Yet, in our study, only 8% of the total sample received a shock of any kind, which may explain why no association between shocks and HCU within the predictor models was found. Nevertheless, it would be valuable for future research to conduct a sub analysis in a larger sample with only ICD recipients who have received shocks, exploring the specific contribution of appropriate and inappropriate shocks to HCU. Previous studies found older age and comorbidities⁹ to be predictors of increased HCU. By contrast, our results showed that younger age was associated with increased HCU, while no association was found with comorbidities. Again, a possible explanation for the latter could be that the WEBCARE sample was relatively healthy. With respect to age, within the ICD population younger age has been associated with poor adjustment postimplantation and increased distress.²⁵ As discussed previously, this may lead to increase of somatic symptoms and associated HCU.

The outcomes of this study stress the necessity for clinicians to be alert to signs of depression (eg, sadness, loss of interest, withdrawing from relatives, nonadherence to treatment, etc.), particularly as of 3 months post-ICD implantation. Since studies show that psychological interventions like cognitive behavioral therapy are beneficial in reducing depressive symptoms in ICD patients,²⁶ referral for psychological help in case of a suspected mood disorder is warranted.

The results of the current study must be interpreted with the following limitations in mind. HCU was assessed using the TiC-P self-report questionnaire. While this is easy and low-cost to use, it may be prone to recall bias and therefore not an entirely accurate representation of HCU. Furthermore, the TiC-P questionnaire has been designed for psychiatric populations and has not been validated for cardiac patients. Therefore, future research should use more objective sources of information to quantify HCU. In addition, HCU over 12 months may be underestimated. As the TiC-P questionnaire assesses HCU 3 months in retrospect, at month 12 the scores reflect HCU between month 9 and 12. As in the WEBCARE study no assessment took place at 9 months; we were not able to assess the level of HCU between 6 and 9 months postimplant. Furthermore, as mentioned previously the WEBCARE sample was relatively higher educated and healthy as compared to other ICD samples. This might have influenced the results and their generalizability to the general ICD population. Finally, given improvements in technology of the ICD during the last decade, the representativeness of the WEBCARE cohort for the current ICD population might be questionable. These innovations have led to a reduction in shocks, and could therefore have an influence on the generalizability of current findings. However, similar levels of depression have been reported by a study in ICD recipients that did use new programming strategies.²⁷ This study also has some advantages. It is the first study to examine HCU in the ICD population, using a

prospective study design in a well-described population. In addition, research shows that only a small number of high-cost utilizers in general keeps using medical resources after a year.⁹

Future studies are warranted that focus on the mechanisms underlying the association between depression and HCU. In addition, it would be valuable to examine which patient profiles are associated with increased HCU in order to develop programs that could provide more personalized care at the right time. Finally, research is warranted to replicate the current findings, using more objective indicators of HCU and associated costs and compare whether there is a discrepancy between objective and subjective indicators of HCU.

In conclusion, this study showed that depression is an important predictor of HCU in ICD patients within the first 12 months postimplantation. The impact of depression on HCU is particularly prominent from 3 months and up to 12 months postimplantation. Within the first 3 months, younger age, NYHA classification (III-IV), and secondary indication showed to be associated with HCU. Future research should focus identifying patients who need additional care and provide this on time in order to better meet patients' needs and lower future HCU.

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CONFLICTS OF INTEREST

None declared.

AUTHOR CONTRIBUTIONS

EB: data analysis/interpretation, statistics, drafting article, critical revision, approval of article, data collection. PL: data analysis/interpretation, statistics, critical revision, approval of article. VS: data interpretation, critical revision, approval of article. JW: data interpretation, critical revision of article, approval of article. SP: concept/design, data interpretation, critical revision of article, approval of article, funding secured by. MH: concept/design, data interpretation, drafting article, critical revision of article, approval of article, data collection.

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