



Personality traits, ventricular tachyarrhythmias, and mortality in patients with an implantable cardioverter defibrillator: 6 years follow-up of the WEBCARE cohort

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ABSTRACT

Objective: Risk stratification within the ICD population warrants the examining of the role of protective- and risk factors. Current study examines the association between Type D personality, pessimism, and optimism and risk of ventricular tachyarrhythmias (VTa's) and mortality in patients with a first-time ICD 6 years post implantation. **Methods:** A total of 221 first-implant ICD patients completed questionnaires on optimism and pessimism (Life Orientation Test) and Type D personality (Type D scale DS14) 10 to 14 days after implantation. VTa's and all-cause mortality 6 years post implant comprised the study endpoints.

Results: Ninety (40.7%) patients had experienced VTa's and 37 (16.7%) patients died, 12 (5.4%) due to a cardiac cause. Adjusted logistic regression analysis showed that pessimism was significantly associated with increased risk of VTa's (OR = 1.09; 95% CI = 1.00–1.19; $p = .05$). Type D personality (OR = 1.05; 95% CI = 0.47–2.32; $p = .91$) and optimism (OR = 1.00; 95% CI = 0.90–1.12; $p = .98$) were not associated with VTa's. None of the personality types were associated with mortality.

Conclusion: Pessimism was associated with VTa's but not with mortality. No significant association with either of the endpoints was observed for Type D personality and optimism. Future research should focus on the coexistent psychosocial factors that possibly lead to adverse cardiac prognosis in this patient population.

1. Introduction

Implantable cardioverter defibrillator (ICD) therapy is the first-line treatment, both as primary (patients who are at risk to experience ventricular tachyarrhythmias (VTa's)) and secondary prevention (patients who have experienced VTa's), for patients at risk of sudden cardiac death (SCD) due to life-threatening VTa's [1]. ICD therapy is associated with better survival as compared to anti-arrhythmic drugs [2], although this remains precarious for particular patient subgroups (e.g. the elderly, primary prevention) [3–5]. Hence, risk stratification with respect to which patients will benefit from implantation with an ICD

still remains a challenge in clinical practice, warranting that we continue to strive to identify risk factors related to VTa's and mortality to further refine prognostic stratification.

Besides clinical risk factors (e.g. left ventricular ejection fraction (LVEF) [1] and shocks [6,7]), a range of emotional factors, such as anxiety [8,9], depression [10], anger [11], ICD concerns [12], post-traumatic stress disorder (PTSD) [13], and impaired quality of life [14] have been shown to contribute to adverse health outcomes, including survival and VTa's in the ICD population. The association between these psychological vulnerability factors and health outcomes are independent of biomedical risk factors and severity of the underlying

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disease [15,16]. Distress is particularly manifest in patients with a Type D personality, who have the tendency to experience negative emotions (e.g. worrying) and not to share these with others [17]. Some studies have found that Type D personality is associated with increased risk of mortality and VTa's [12,18] in the ICD population, while other studies found no association [15,19]. Furthermore, it is unclear whether the association persists over a prolonged period of time. It is observed that anxious and depressed ICD patients tend to have a more overall pessimistic view of the world that may result in adverse health outcomes [20,21]. On the other hand, evidence suggests that dispositional optimism (e.g. the overall tendency to have positive expectations about future outcomes) is protective [21] and also associated with better health behaviours [22,23], better health outcomes [24], and reduced mortality risk [24] in the general cardiac population. As we do not know whether this is generalizable to the ICD population, it is important to examine whether specific personality traits make patients vulnerable or resilient for VTa's and mortality on the long-term. This might provide opportunities to optimize healthcare based on patients' preferences and needs, which in turn might lead to better clinical outcomes for specific ICD patient subgroups.

Hence, the objective of the current study was to examine the association between Type D personality, pessimism, and optimism and risk of mortality and VTa's in patients with a first-time ICD 6 years post implantation.

2. Methods

2.1. Patient population and procedure

Consecutive patients implanted with a first-time ICD between April 2010 and February 2013 enrolled in the WEB-based distress management program for implantable CARdioverter dEfibrillator patients (WEBCARE), a multicenter randomized controlled trial, comprised the study cohort [25]. Patients were recruited 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).

Patients between 18 and 75 years of age, who underwent a first-time ICD implantation were approached for participation by an ICD nurse or technician. Patients with significant cognitive impairments (e.g. dementia), history of psychiatric illness other than depressive or anxiety disorders, life expectancy < 1 year, on the waiting list for heart transplantation, life-threatening comorbidities (e.g. malignancies), lack of internet/computer skills, or insufficient knowledge of the Dutch language were excluded. Participants were requested to complete a set of validated and standardized questionnaires in the first year post implant (i.e., at baseline, 3-, 6-, and 12 months). More details on the study procedure has been described elsewhere [26]. The study was conducted according to the ethical guidelines of the Helsinki Declaration, and the protocol has been approved by the Medical Ethical Committees of all participating centres (METC number MEC-2009-211/NL25617.078.09; NCT00895700). All participants were informed orally and in writing about the study and all provided written informed consent.

2.2. Measurements

2.2.1. Sociodemographic and clinical variables

Purpose-designed questionnaires were used at baseline to collect information on patients' age and gender (i.e. 0 'male' and 1 'female'). Information on clinical variables was obtained from patients' medical records and included systolic dysfunction (LVEF), ICD indication (primary versus secondary), aetiology of CAD (i.e. 0 'no' and 1 'yes'), ICD shocks (i.e. 0 'no' and 1 'yes' and 'appropriate and inappropriate'). Comorbidities were assessed with the Charlson Comorbidity Index (CCI).

2.2.2. Type D personality

Type D personality was assessed with the Type D scale (DS14) [27]. This self-report questionnaire consists of two distinct subscales comprised of 7 items each, i.e. Social Inhibition (SI) (e.g. "I am a 'closed' kind of person") and Negative Affectivity (NA) (e.g. "I am often irritated"). Items are answered on a 5-point Likert scale ranging from 0 (false) to 4 (true), with total scores on the scales ranging from 0 to 28. Type D is defined by a standardized cut-off score of ≥ 10 on both subscales. The questionnaire is internally consistent, with Cronbach's alpha's of 0.86 for SI and 0.88 for NA, respectively [27]. Previous research has shown that Type D personality is a stable construct over time [28].

2.2.3. Optimism and pessimism

The Life Orientation Test (LOT) was used to assess the personality traits optimism and pessimism [29]. The total questionnaire consists of 12 items that are answered on a 5-point Likert scale, ranging from 0 (very much disagree) to 4 (very much agree). The construct of optimism is comprised of 4 items (e.g. "In uncertain times, I usually expect the best") while 4 items contribute to the construct of pessimism (e.g. "I hardly ever expect thing to go my way"). The remaining 4 items do not contribute to the sum score, as they represent 'filler items'. Both subscales have a total score range from 0 to 16, with a higher score reflecting a higher level of the respective traits.

2.3. Study endpoints

The study endpoints were all-cause mortality and VTa's 6 years post ICD implant. The follow-up time ranged from 4 to 7 years, with a mean of 5.82 ± 0.81 years (IQR = 1). Not all centres were able to provide information on cause of death. Therefore, cardiac-related mortality could not been included as an endpoint separately. Information on mortality and VTa's were obtained from the patients' medical records. Based on stored electrograms and ICD data, electrophysiologists and/or the treating cardiologists judged the appropriateness of ICD therapies. Cause of death and date were derived from patients' medical record by the cardiologists associated with the recruitment centre.

2.4. Statistical analysis

Baseline characteristics were assessed using mean scores with standard deviations (SD) (continuous variables) and frequencies (categorical variables) for descriptive purposes. These are presented as means \pm SD and percentages for the total sample. In order to handle missing data, pairwise deletion was performed. Chi-square tests and *t*-tests were performed in order to examine potential systematic differences between patients who were included in the analysis and patients who were excluded. Univariable and multivariable hierarchical binary logistic regression analyses were performed to examine the associations between different personality traits (i.e., optimism, pessimism, Type D) and VTa's. Cox-Regression analysis was performed to examine the association between personality traits and all-cause mortality. A priori based on the literature, we had decided to adjust all multivariable models for demographic (gender, age) and clinical (LVEF, ICD indication, CAD aetiology, shocks, CCI) covariates. New York Heart Association (NYHA) functional class was not included into the models because of missing data ($N = 186$). Instead, we added LVEF as indication of heart disease severity [30]. Shocks were excluded as a covariate in the analysis on ventricular arrhythmias. In the first model, the different personality traits were entered separately (optimism, pessimism, or Type D) for all-cause mortality and VTa's, respectively. In model 2, model 1 was adjusted for the aforementioned demographic covariates. Finally, the medical covariates were added in model 3. Assumptions for all multivariable analyses were checked and met. A *p*-value of < .05 was considered statistically significant. IBM SPSS Statistics version 24 was used to perform all analyses.

Table 1
Patient baseline characteristics of the total sample.

	Total	Ventricular tachyarrhythmia's			All-cause mortality		
	N = 221	N = 90	N = 131		N = 34	N = 184	
		Yes	No	p	Yes	No	p
Demographic							
Sex (female)	37(16.7)	8(21.6)	29 (78.4)	0.02	6(16.2)	31(83.8)	1.00
Age	58.9 ± 9.9	58.6 ± 9.7	59.2 ± 10.0	0.67	64.1 ± 6.5	58.0 ± 10.1	0.001
Clinical							
Secondary indication	63(28.5)	36(57.1)	27(42.9)	0.003	8(12.7)	55(87.3)	0.59
Shocks (any)	59(26.7)	–	–	–	10(16.9)	49(83.1)	0.90
Ischemic heart disease	138(62.4)	55 (39.9)	83(60.1)	0.84	24(17.6)	112(82.4)	0.38
CCI	1.69 ± 0.9	1.6 ± 0.8	1.7 ± 1.1	0.55	2.2 ± 1.4	1.6 ± 0.9	0.002
LVEF	31.3 ± 12.2	32.3 ± 12.4	30.8 ± 12.0	0.38	29.8 ± 9.8	31.8 ± 12.6	0.38
Medication							
Beta-blockers	183(82.8)	68(37.2)	115(62.8)	0.03	26(14.4)	155(85.6)	0.39
Diuretics	114(51.4)	40(35.1)	74(64.9)	0.11	20(17.9)	92(82.1)	0.45
ACE-inhibitors	146(66.1)	53(36.3)	93(63.7)	0.09	20(13.9)	124(86.1)	0.44
ARB	34(15.4)	16(47.1)	18(52.9)	0.53	5(15.2)	28(84.8)	1.00
Statins	148(67.0)	60(40.5)	88(59.5)	1.00	23(15.8)	123(84.2)	1.00
Amiodarone	19(8.6)	11(57.9)	8(42.1)	0.18	5(26.3)	14(73.7)	0.31
Digoxine	10(4.5)	1(10.0)	9(90.0)	0.09	2(20.0)	8(80.0)	1.00
Psychotropic medication	15(6.8)	10(66.7)	5(33.3)	0.07	3(20.0)	12(80.0)	0.91
Psychological							
Optimism	11.3 ± 2.6	11.3 ± 2.7	11.3 ± 2.6	0.91	11.2 ± 2.9	11.3 ± 2.6	0.78
Pessimism	5.6 ± 3.3	6.1 ± 3.6	5.3 ± 3.0	0.06	5.9 ± 3.5	5.5 ± 3.2	0.51
Type D personality	32(14.5)	14(43.8)	18(56.3)	0.86	5(16.1)	26(83.9)	1.00

ACE-inhibitors = angiotensin converting enzyme inhibitors; ARB = angiotensin receptor blocker; CCI = Charlson comorbidity index; LVEF = left ventricular ejection fraction.

For continuous variables mean ± SD is reported; for categorical variables N(%) is reported.

3. Results

3.1. Patient characteristics

Of 1024 patients approached for participation, 562 were eligible for study inclusion. Of the 562 patients, 340 patients signed informed consent. Because of missing data on dependent and independent variables, 35% ($n = 119$) of patients were excluded from analysis, leaving 221 patients in the analysis with respect to VTa's. From 3 additional patients it was not possible to establish the data of death. Hence, these patients were excluded from the all-cause mortality analysis, resulting in $N = 218$ for those models. Patients excluded from analysis were less likely to use ACE inhibitors ($p < .01$), statins ($p < .01$), and more likely to use psychotropic medication ($p = .02$). No other systematic differences between included and excluded patients on baseline characteristics were found. Baseline characteristics of the current sample are presented in Table 1. The majority of patients were male (184/221, 83.3%), with a mean age of 58.95 ± 9.88 years at the time of implantation. During the follow-up period, 59 (26.7%) patients received a shock (either appropriate and/or inappropriate), 90 (40.7%) had experienced VTa's, 37 (16.7%) patients died of which 12 (5.4%) patients died due to a cardiac cause. No information on the other causes of death was available.

3.2. Type D personality, ventricular arrhythmias and all-cause mortality

Type D personality was not significantly associated with VTa's (OR = 1.16; 95% CI = 0.54–2.46; $p = .71$) in univariable analysis. This association remained non-significant (OR = 1.08; 95% CI = 0.50–2.33; $p = .85$) after adding age and gender as covariates in Model 2 (χ^2 (3, $N = 221$) = 8.10, $p = .04$). Being female was associated with a decreased risk of VTa's (OR = 0.32; 95% CI = 0.14–0.75; $p < .01$). In Model 3, clinical covariates were additionally added as covariates (i.e., ICD indication, LVEF, CCI, CAD aetiology). The

association between Type D personality and VTa's remained non-significant (OR = 1.05; 95% CI = 0.47–2.32; $p = .91$). Of the covariates, female gender persisted to be associated with a decreased risk (OR = 0.36; 95% CI = 0.15–0.87; $p = .02$), while secondary ICD indication was associated with an increased risk of VTa's (OR = 2.40; 95% CI = 1.21–4.78; $p = .01$). No significant associations were observed between the other covariates that were added to the model and outcomes (see Table 2).

With respect to all-cause mortality, univariable analysis showed no significant association with Type D personality (HR = 0.81; 95% CI = 0.31–2.15; $p = .67$). This finding did not change after the adjustment for demographic (i.e., age and gender – Model 2) and clinical (ICD indication, CAD aetiology, shocks, CCI, and LVEF – Model 3) variables. None of the covariates in the model were associated with the study endpoint (see Table 2).

3.3. Pessimism, ventricular arrhythmias and all-cause mortality

With respect to VTa's, univariable logistic regression analysis showed no significant association with pessimism (OR = 1.08; 95% CI = 1.00–1.18; $p = .06$). When adding demographic covariates (i.e. age and gender) in Model 2 (χ^2 (3, $N = 221$) = 11.69, $p < .01$), pessimism remained a non-significant correlate of VTa's (OR = 1.09; 95% CI = 1.00–1.18; $p = .06$). Of the covariates, only female gender was a significant correlate of decreased risk of VTa's (OR = 0.32; 95% CI = 0.14–0.75; $p < .01$). In model 3 (χ^2 (7, $N = 221$) = 20.08, $p < .01$), pessimism was significantly associated with an increased risk (OR = 1.09; 95% CI = 1.00–1.19; $p = .050$), after controlling for gender, ICD indication, CAD aetiology, CCI, and LVEF (see Table 3). The association between female gender and VTa's remained significant (OR = 0.35; 95% CI = 0.14–0.86; $p = .02$). Secondary ICD indication was associated with an increased risk of VTa's (OR = 2.43; 95% CI = 1.21–4.88; $p = .01$). No other significant associations were found (see Table 3).

Table 2
Associations between Type D personality and ventricular arrhythmias and all-cause mortality.^f

	Ventricular arrhythmias						All-cause mortality		
	B	S.E.	Wald	OR	95% CI	p	HR	95%CI	p
Model 1									
Type D	0.15	0.39	0.14	1.16	0.54–2.46	0.70	0.81	0.31–2.15	0.67
Model 2									
Type D	0.08	0.39	0.04	1.08	0.50–2.33	0.85	0.74	0.25–2.21	0.59
Age	−0.01	0.01	0.84	0.99	0.96–1.02	0.34	1.07	0.99–1.15	0.07
Gender ^a	−1.14	0.43	6.82	0.32	0.14–0.75	< 0.01	0.83	0.30–2.30	0.71
Model 3									
Type D	0.05	0.41	0.01	1.05	0.47–2.32	0.91	0.95	0.29–3.15	0.94
Age	−0.01	0.02	0.40	0.99	0.96–1.02	0.53	1.07	0.99–1.15	0.07
Gender	−1.03	0.45	5.17	0.36	0.15–0.87	0.02	0.90	0.31–2.57	0.84
LVEF ^b	−0.003	0.01	0.05	1.00	0.97–1.02	0.83	1.00	0.96–1.04	0.97
Indication ^c	0.88	0.35	6.02	2.40	1.21–4.78	0.01	0.75	0.27–2.11	0.59
IHD	−0.22	0.32	0.47	0.80	0.43–1.50	0.49	1.54	0.64–3.72	0.34
Shocks ^d	–	–	–	–	–	–	0.58	0.23–1.48	0.25
CCI ^e	−0.01	0.16	0.003	0.99	0.73–1.35	0.96	0.99	0.73–1.34	0.92

CCI = Charlson comorbidity index; IHD = ischemic heart disease.

^a Male.

^b Continuous scale.

^c Primary indication.

^d Appropriate or inappropriate shocks: yes.

^e Continuous scale.

^f Logistic regression analysis.

In unadjusted analysis, pessimism was not significantly associated with all-cause mortality (HR = 1.01; 95% CI = 0.91–1.12; $p = .91$). After the addition of age and gender in Model 2, the association with pessimism was unchanged. The association between pessimism and mortality remained non-significant in Model 3 after adjustment for ICD indication, LVEF, shocks, history of ischemic heart disease, CCI, age, and gender. None of the covariates were associated with mortality (see Table 3).

3.4. Optimism, ventricular arrhythmias and all-cause mortality

In the unadjusted binary logistic regression analysis, no significant

association was found between optimism and VTa's (OR = 0.99; 95% CI = 0.90–1.10; $p = .91$) (see Table 4). After adjustment for age and gender in model 2 (χ^2 (3, $N = 221$) = 8.09, $p = .04$), optimism remained non-significant (OR = 1.01; 95% CI = 0.91–1.12; $p = .88$), while being female was significantly associated with a decreased risk of VTa's (OR = 0.32; 95% CI = 0.14–0.75; $p < .01$). In model 3 (χ^2 (7, $N = 221$) = 16.16, $p = .02$), after additional adjustment for ICD indication, CAD aetiology, CCI, and LVEF, the association between optimism and VTa's did not change (OR = 1.00; 95% CI = 0.90–1.12; $p = .98$). Again, being female was associated with decreased risk of VTa's (OR = 0.35; 95% CI = 0.15–0.87; $p = .02$). Secondary ICD indication was associated with an increased risk (OR = 2.40; 95%

Table 3
Associations between pessimism and ventricular arrhythmias and all-cause mortality.^f

	Ventricular arrhythmias						All-cause mortality		
	B	S.E.	Wald	OR	95% CI	p	HR	95% CI	p
Model 1									
Pessimism	0.08	0.04	3.51	1.08	1.00–1.18	0.06	1.01	0.91–1.12	0.91
Model 2									
Pessimism	0.08	0.04	3.55	1.09	1.00–1.18	0.06	1.03	0.91–1.16	0.69
Age	−0.01	0.02	0.94	0.99	0.96–1.02	0.33	1.06	0.99–1.14	0.12
Gender ^a	−1.15	0.44	6.92	0.32	0.16–0.75	< 0.01	0.64	0.21–1.93	0.43
Model 3									
Pessimism	0.09	0.05	3.83	1.09	1.00–1.19	0.050	1.03	0.90–1.17	0.66
Age	−0.01	0.02	0.49	0.99	0.96–1.02	0.49	1.07	0.99–1.15	0.09
Gender	−1.05	0.46	5.28	0.35	0.14–0.86	0.02	0.82	0.26–2.54	0.72
LVEF ^b	−0.002	0.01	0.02	1.00	0.97–1.03	0.89	0.99	0.96–1.04	0.96
Indication ^c	0.89	0.36	6.25	2.43	1.21–4.88	0.01	0.82	0.27–2.43	0.72
IHD	−0.24	0.32	0.55	0.79	0.42–1.48	0.46	1.60	0.68–3.73	0.28
Shocks ^d	–	–	–	–	–	–	0.59	0.23–1.48	0.26
CCI ^e	−0.004	0.16	0.001	1.00	0.73–1.36	0.98	0.98	0.74–1.30	0.90

CCI = Charlson comorbidity index; IHD = ischemic heart disease.

^a Male.

^b Continuous scale.

^c Primary indication.

^d Appropriate or inappropriate shocks: yes.

^e Continuous scale.

^f Logistic regression analysis.

Table 4
Associations between optimism and ventricular arrhythmias and all-cause mortality.^f

	Ventricular arrhythmias						Cause mortality		
	B	S.E.	Wald	OR	95% CI	p	HR	95% CI	p
Model 1									
Optimism	−0.006	0.05	0.01	0.99	0.90–1.10	0.91	0.92	0.81–1.05	0.23
Model 2									
Optimism	0.01	0.05	0.03	1.01	0.91–1.12	0.88	0.94	0.83–1.08	0.38
Age	−0.01	0.01	0.88	0.99	0.96–1.02	0.35	1.06	0.99–1.14	0.12
Gender ^a	−1.15	0.44	6.90	0.32	0.14–0.75	< 0.01	0.74	0.30–1.84	0.51
Model 3									
Optimism	0.002	0.06	0.001	1.00	0.90–1.12	0.98	0.97	0.84–1.13	0.71
Age	−0.01	0.02	0.42	0.99	0.96–1.02	0.52	1.07	0.99–1.15	0.08
Gender	−1.04	0.46	5.18	0.35	0.15–0.87	0.02	0.86	0.30–2.50	0.79
LVEF ^b	−0.003	0.01	0.05	1.00	0.97–1.02	0.83	1.00	0.96–1.05	0.92
Indication ^c	0.88	0.35	6.18	2.40	1.20–4.78	0.01	0.80	0.27–2.35	0.68
IHD	−0.22	0.32	0.49	0.80	0.43–1.49	0.48	1.46	0.60–3.59	0.41
Shocks ^d	–	–	–	–	–	–	0.58	0.23–1.48	0.25
CCI ^e	−0.01	0.16	0.002	0.99	0.73–1.35	0.98	1.01	0.74–1.37	0.98

CCI = Charlson comorbidity index; IHD = ischemic heart disease.

All p values equal to or below .05 are bold

This is the trait of interest in this table hence *Italic*

^a Male.

^b Continuous scale.

^c Primary indication.

^d Appropriate or inappropriate shocks: yes.

^e Continuous scale.

^f Logistic regression analysis.

CI = 1.20–4.78; $p = .01$). No significant influences of other covariates were found (see Table 4).

Regarding all-cause mortality, the unadjusted logistic regression analysis showed no significant association with optimism (HR = 0.92; 95% CI = 0.81–1.05; $p = .23$). In model 2, adding age and gender as covariates, the association of optimism with mortality remained unchanged. After additional adjustment for clinical covariates in Model 3, the influence of optimism remained non-significant. Other covariates were not significantly associated with all-cause mortality (see Table 4).

4. Discussion

The aim of the current study was to investigate the association between personality traits and VTa's and all-cause mortality, respectively, in a consecutive cohort of patients with a first-time implant ICD during 6 years of follow-up. We did not find a significant association between Type D personality and VTa's nor between Type D and mortality. The results for optimism were similar. By contrast, pessimism was associated with increased risk of VTa's after statistical adjustment for possible confounding clinical and demographic variables. No association between pessimism and all-cause mortality was observed.

The lack of significant association between Type D personality and VTa's and mortality, respectively, is not in line with previous studies in ICD patients [12,18]. The incongruent findings across studies on Type D and health outcomes in the ICD population may be explained by heterogeneity in follow-up duration (e.g. short-term), sample size (e.g. large sample sizes), and different statistical methods used for data analyses (e.g. survival analysis). As current study involves a long-term follow-up period of six years, the incongruity with previous findings might indicate that the predictive value of Type D personality on survival within the ICD population is hypothetically short-term. Another reason for the current negative findings could be the use of all-cause rather than cardiac-related mortality as endpoint [31,32]. The association between Type D personality and mortality is believed to work through biological, disease-specific mechanistic pathways (e.g. increased pro-inflammatory cytokines) and is therefore expected to be markedly more related to cardiac mortality and morbidity [33]. It was

not possible for all centers to provide information on cause of death. Hence, we were not able to look at cardiac-related mortality separately. Moreover, previous research has shown that the combination of Type D personality and anxiety or concerns about ICD treatment increases the risk of mortality [12] or VTa's [34], suggesting a possible cumulative effect of co-existing emotional and personality factors and that psychosocial risk factors often cluster together to influence health outcomes [35]. Therefore, future research should focus on the interplay between psychological states and underlying personality traits in order to design effective interventions that meet patients' needs in order to improve patients' outcomes. Moreover, although the general perception is that personality is stable and difficult to change [36], previous research has shown that certain interventions (e.g. cognitive behavioural therapy, assertiveness training) are of beneficial value for interpersonal functioning of Type D patients [37] and may thus provide opportunities for improvement of negative outcomes within this population.

In the current study, we also found that women had a decreased risk of VTa's as compared to men. Previous research has shown that electrophysiological parameters prone to the effect of sex hormones (i.e. oestrogen, testosterone), resulting in a difference in risk for VTa's between men and women [38]. This suggests a more gender specific approach of care needed in the ICD population. With respect to current findings, future studies should look into possibilities to design interventions which aim to reduce pessimism. Evaluating whether these interventions are effective and also reduce the risk of adverse outcomes would provide a stronger evidence base and could be implemented in the clinical practice.

To the best of our knowledge, this is one of the first studies examining the association between dispositional pessimism and adverse outcomes in ICD patients. An increased risk was found for VTa's in relation to pessimism. This finding could be explained by the interrelation between dispositional pessimism, negative emotions and sympathetic nervous system activation [39]. According to Lampert [40], VTa's are linked with negative emotions by their altering effect on the autonomic nervous system. This alteration may lead to insufficient repolarisation of the myocardium and VTa's in vulnerable patients [41]. We found no significant association between optimism and VTa's and mortality,

respectively. Previous research in multiple cardiac populations has found that dispositional optimism may protect against negative health related outcomes, such as mortality [24] and health related quality of life [42]. This is at odds with our finding, which may be attributed to the relatively small sample size of the WEBCARE cohort. Speculatively, it is also possible that optimism might only be protective on the short-but not long-term in the ICD population or that the effect of optimism on health-related outcomes might be mediated by other psychosocial factors (e.g. treatment expectations [43]) not added in our analyses. Hence, future research should look into potential mediating mechanisms and duration of potential protective effect of positive psychological factors and health outcomes.

Optimism and pessimism are not necessarily traits that are at opposite ends of the same continuum but may coexist [44], providing opportunities for intervention. Thus, enhancing positive psychological states on a low-threshold basis could lead to beneficial health outcomes in ICD patients [45]. In order to reach their full potential, it is suggested to combine positive psychology interventions with stress reducing techniques and physical activity [46]. Toise et al. [47] showed in a yoga pilot intervention that aimed to reduce distress in ICD patients a decreased risk of VTa's, less concerns about the ICD firing, and more self-compassion in the intervention group compared to the control condition. Therefore, focusing on patients' personality and needs in clinical care could be of added value in addition to interventions already offered through existent routine clinical pathways.

The results of the current study should be interpreted with the following limitations in mind. First, because of lack of information on the 'time-to-event', we could not perform Cox regression analyses. Second, medical records frequently did not provide information on the cause of death of patients, which resulted in ambiguity with respect to cause of death (i.e., all-cause versus cardiac), which may have influenced the results. Third, the relatively small sample size has limited the number of covariates that we could include in the statistical analyses. Hence, possibly important covariates such as psychiatric illness or medication use were not included in the models. Finally, patients who were excluded from the analysis were more likely to use psychotropic medication, this might have resulted in an underrepresentation of this group in the current sample. A large scale study covering a more representative sample is advocated in the future. Despite these limitations, this study is one of only few studies that have looked at the association between psychosocial factors in relation to mortality and VTa's in ICD patients with a long-term follow-up.

In conclusion, the findings of the current study have shown no effect of Type D personality and dispositional optimism on VTa's and mortality in ICD patients. However, an association between pessimism and VTa's was distinguished. Further, sufficiently powered studies, applying more robust statistical methods (e.g. survival analysis) are warranted to confirm our finding that pessimism is related to VTa's in ICD patients, with respect to optimizing risk stratification. Future research should also focus on the coexistent psychosocial factors that possibly lead to worse adverse cardiac prognosis in this patient population (such as psychiatric disorders, low socioeconomic status). Insight into these factors could lead to interventions that meet patients' needs to a bigger extent and favour the inhibition of disease progression.

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CRediT authorship contribution statement

E.R. Broers: Formal analysis, Writing - original draft. **M. Habibović:** Project administration, Formal analysis, Writing -

original draft, Writing - review & editing. **J. Denollet:** Supervision, Methodology, Writing - review & editing. **J.W.M.G. Widdershoven:** Supervision, Writing - review & editing. **M. Alings:** Data curation, Writing - review & editing. **D.A.M.J. Theuns:** Data curation, Writing - review & editing. **P. van der Voort:** Data curation, Writing - review & editing. **L. Bouwels:** Data curation, Writing - review & editing. **J.P. Herman:** Data curation, Writing - review & editing. **S.S. Pedersen:** Funding acquisition, Methodology, Writing - original draft, Writing - review & editing.

Declaration of competing interest

None declared.

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