

RESEARCH ARTICLE

Negative affectivity and social inhibition are associated with increased cardiac readmission in patients with heart failure: A preliminary observation study

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Abstract

Background

Type D personality was hypothesized to influence clinical and patient-centered outcomes patients with heart failure. The aim of this study was to investigate the association between negative affectivity and social inhibition components of Type D personality and cardiac readmission in patients with heart failure.

Methods

A prospective observational study design was used. A total of 222 patients with heart failure were recruited from the department of cardiology in two regional hospitals in Taiwan. The 14-item Type D Scale-Taiwanese version was used to assess negative affectivity and social inhibition of the patients. Logistic regression analyses were conducted to determine the association of both Z-score transformed and dichotomized negative affectivity and social inhibition with 6-month and 18-month cardiac readmissions.

Results

A total of 55 patients (24.8%) and 89 patients (40.1%) had cardiac readmissions within 6 months and 18 months, respectively. Multiple logistic regression analyses of Z-score transformed negative affectivity and social inhibition were significantly associated with (1) 6-month cardiac readmission with odds ratios of 1.62 ($P = 0.003$) and 1.48 ($P = 0.014$), respectively and (2) 18-month cardiac readmission with odds ratios of 1.45 ($P = 0.013$) and 1.38 ($P = 0.031$), respectively. Similar findings were obtained when negative affectivity and social inhibition were analyzed as dichotomized scores.

Conclusions

Negative affectivity and social inhibition components of the Type D personality were significantly associated with a higher risk of cardiac readmission in both 6 months and 18 months after the initial hospitalization in patients with heart failure.

Introduction

Heart failure is chronic, progressive condition in which the heart is unable to provide adequate blood flow to meet the body's needs for blood and oxygen. It is a pandemic affecting at least 26 million people worldwide [1]. The prevalence of heart failure was estimated to increase from 0.7% in persons aged 45–54 years to over 10% in those aged 85 years or older [2]. In the United States, an estimated 5.7 million people have heart failure, and the annual cost for treatment of heart failure has been estimated to be over 32 billion US dollars [3]. In addition, heart failure is a common cause of unplanned hospital admissions and readmissions [4]. About half of the patients with heart failure were readmitted to a hospital within 6 months of discharge [5]. Unplanned readmissions after initial hospitalization can significantly increase the costs of health care and affect the quality of life in patients with heart failure [6, 7]. Therefore, there is an ongoing need to identify factors to reduce readmissions after heart failure hospitalization [8].

A systematic review examined patient-level characteristics associated with readmission and found that age and sex were the most commonly included variables in readmission models, but there was no consistent association among other covariates, such as diabetes mellitus and hypertension. An increased in the biomarker B-type natriuretic peptide was shown to be consistently associated with readmission [9]. Another systematic review revealed that noncardiovascular comorbidities, poor physical condition, a history of admission, and failure to use evidence-based medication were significantly associated with 90-day readmission in patients with heart failure [10]. A study based on the secondary analysis of an administrative database in Japan showed that older age, lower body mass index, higher New York Heart Association (NYHA) functional classification at admission, higher Charlson Comorbidity Index, shorter length of stay in a hospital, and use of beta blockers, loop diuretics, thiazide, and nitrates at discharges were associated with an increased risk in 30-day readmission in patients with heart failure. Conversely, the use of angiotensin-converting enzyme inhibitors (ACEs) or angiotensin II receptor blockers (ARBs), calcium-channel blockers, and spironolactone were associated with a decreased risk [11].

Recently, it has been hypothesized that Type D personality could be associated with clinical and patient-centered outcomes and self-care in patients with heart failure, possibly through the involvement of the sympathetic nervous system, inflammation, and oxidative stress pathophysiological pathways [12]. Nevertheless, the evidence is less consistent compared with the association between Type D personality and coronary artery disease [13–15]. The distressed personality construct (Type D) is a relatively stable personality disposition that refers to the joint tendency towards negative affectivity (NA) and social inhibition (SI). Individuals with high NA scores exhibit a tendency to experience negative emotions, while those with high scores on SI tend to inhibit their emotions and behaviors in social situations [16]. While there were studies evaluating the Type D personality and medication adherence [17] and self-care behaviors [18] in patients with heart failure, to the best of our knowledge, no studies have investigated the association between Type D personality and the risk of cardiac readmission in

these patients. Therefore, the aim of this study was to investigate the association between NA and SI components of Type D personality and cardiac readmission in patients with heart failure.

Methods

Study design and participants

A prospective observational study design was used to assess the factors associated with 6-month and 18-month cardiac readmission in patients with heart failure. Using convenience sampling, inpatients with heart failure were recruited from the department of cardiology in two regional teaching hospitals in Taiwan. Inclusion criteria included patients with a NYHA functional classification ≥ 2 and data on left ventricular ejection fraction (LVEF) available within 6 months of the admission. Patients with the following conditions were excluded: cancer, bedridden for over 3 months, severe visual or hearing impairment, and psychiatric disorders. Patients with psychiatric disorders were ascertained by a self-reported questionnaire with questions on whether they had received any mental health care in the past or had any physician-diagnosed psychiatric disorders. A total of 269 patients were eligible for the study but only 222 patients were included in the analysis. Forty-seven patients were excluded due to the following reasons: death (2 patients), incomplete questionnaire (21 patients), and lost to follow-up or refused to participate in the study during follow-up (24 patients).

The study protocol was approved by the Institutional Review Board of Dalin Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Taiwan (No. B10004009-1). Written informed consent was obtained from all participants.

Questionnaire

The 14-item Type D Scale-Taiwanese version (DS14-T) [19], originally developed by Denollet [13] was used to assess NA and SI of the patients. The NA and SI components each contain seven items with a 5-point Likert scale (0–4 range). The original scale showed good psychometric properties (Cronbach $\alpha = 0.88$ and 0.86 ; 3-month test-retest reliability = 0.72 and 0.82 for NA and SI, respectively) [13]. The DS14-T also demonstrated good internal consistency (Cronbach $\alpha = 0.86$ and 0.79), with factor analyses confirmed the two-factor model of the Type D construct [19]. Since the issue whether Type D personality is better represented by a continuous or dichotomous construct is yet unresolved [20–22], separate analyses using either continuous scores or the dichotomous classification for NA and SI were conducted in this study.

Information on age, sex, body weight, body height, smoking habit, LVEF, NYHA functional classification, comorbidity, and medication use were also ascertained from medical records.

Outcome measurement

Unplanned cardiac-related hospital readmission 6 months and 18 months following discharge were the main outcomes of this study. Cardiac readmission was defined based on

International Statistical Classification of Diseases and Related Health Problems, 9th revision, (ICD-9) diagnosis codes 390–398, 401–405, 410–414 and 420–429 or patients when admitted to cardiac wards (either internal medicine or surgical ward). Readmissions within 6 months or 18 months were ascertained either from the electronic medical records database of the study hospital or by telephone interview.

Statistical analysis

Categorical variables were expressed as number with percentage and continuous variables as mean and standard deviation. To aid the interpretation of the results for NA and SI, their values were transformed Z-scores with a mean of zero and a standard deviation (SD) of 1. Univariate and multiple logistic regression analyses were conducted to determine the association of Z-score transformed NA and SI with 6-month and 18-month cardiac readmissions. In addition, NA and SI were also analyzed as dichotomized scores using the standard cut-off of ≥ 10 [13]. Independent variables evaluated during model development included: sex, age, body mass index, smoking, left ventricular ejection fraction, New York Heart Association functional classification, Beck Depression Inventory, type 2 diabetes, kidney disease, hypertension, coronary heart disease, arrhythmia, diuretics, beta-blockers, angiotensin-converting enzyme inhibitors, and angiotensin II receptor blockers. Backward elimination method based on likelihood ratio test was used for selection of covariates in the multiple logistic regression models. All analyses were performed with SPSS (version 24.0) (SPSS Inc., Chicago, IL, USA), and a *P*-value of 0.05 was considered significant.

Results

The basic characteristics of the study participants at baseline are presented in Table 1. Patients with Type D personality, compared with non-Type D personality, were not significantly different in age, body mass index, and the distribution of sex, NYHA functional classification, smoking, comorbidities, and use of medications, but the mean score of Beck Depression Inventory was significantly higher in patients with Type D personality ($P < 0.001$). A total of 55 patients (24.8%) and 89 patients (40.1%) had cardiac readmissions within 6 months and 18 months, respectively.

Table 2 shows the results of the univariate logistic regression analyses of Z-score transformed NA and SI, as well as the dichotomized NA and SI scores, for 6-month and 18-month cardiac readmission in patients with heart failure. For the 6-month cardiac readmission, the risk of readmission was significantly higher in patients with a higher Z-score transformed NA (odds ratio [OR] = 1.52 for a one SD increase in Z-score transformed NA, 95% confidence interval [CI] = 1.12–2.06, $P = 0.007$). The risk of readmission showed a trend of increase for patients with a higher Z-score transformed SI (OR = 1.34 for a one SD increase in Z-score transformed SI, 95% CI = 1.00–1.79, $P = 0.052$). Similar results were observed for the 18-month cardiac readmission. The risk of readmission was significantly higher in patients with a higher Z-score transformed NA (OR = 1.45 for a one SD increase in Z-score transformed NA, 95% CI = 1.10–1.92, $P = 0.009$). The risk of readmission showed a trend of increase for patients with a higher Z-score transformed SI (OR = 1.26 for a one SD increase in Z-score transformed SI, 95% CI = 0.96–1.65, $P = 0.089$). Furthermore, for the dichotomized scores, the risk of 6-month readmission was significantly higher in patients with either NA or SI (OR = 2.14, 95% CI = 1.09–4.20, $P = 0.027$) and OR = 2.13, 95% CI = 1.06–4.28, $P = 0.034$, respectively). The risk of 18-month readmission was significantly higher in patients with NA but marginally with SI (OR = 2.08, 95% CI = 1.11–3.91, $P = 0.022$) and OR = 1.86, 95% CI = 0.97–3.58, $P = 0.062$, respectively).

Table 3 shows the results of multiple logistic regression analyses of Z-score transformed NA and SI, as well as the dichotomized NA and SI scores, for 6-month and 18-month cardiac readmission in patients with heart failure. Both Z-score transformed NA and SI were significantly associated with either 6-month or 18-month cardiac readmission. The adjusted ORs of 6-month cardiac readmission were 1.62 (95% CI = 1.18–2.23, $P = 0.003$) and 1.48 (95% CI = 1.08–2.02, $P = 0.014$) for Z-score transformed NA and SI, respectively. The adjusted ORs

Table 1. Basic characteristics of patients with heart failure at baseline (N = 222).

| Variable | n (%) | | | P |
|--|------------------|------------------|-------------------|--------|
| | Total | Type D | Non-Type D | |
| | 222 (100) | 23 (10.4) | 199 (89.6) | |
| Sex, n (%) | | | | 0.410 |
| female | 75 (33.8) | 6 (26.1) | 69 (34.7) | |
| male | 147 (66.2) | 17 (73.9) | 130 (65.3) | |
| Age, mean (SD), years | 60.4 (12.1) | 59.6 (11.8) | 60.5 (12.2) | 0.727 |
| BMI, mean (SD), kg/m ² ^a | 26.0 (4.8) | 25.7 (4.4) | 26.0 (4.9) | 0.784 |
| NYHA functional classification, n (%) | | | | 0.844 |
| II | 61 (27.5) | 6 (26.1) | 55 (27.6) | |
| III | 75 (33.8) | 9 (39.1) | 66 (33.2) | |
| IV | 86 (38.7) | 8 (34.8) | 78 (39.2) | |
| Left ventricular ejection fraction (%) | 42.8 (17.9) | 41.3 (16.1) | 43.0 (18.1) | 0.659 |
| Smoking, n (%) | 99 (44.6) | 11 (47.8) | 88 (44.2) | 0.742 |
| BDI, mean (SD) | 5.32 (6.01) | 14.26 (9.75) | 4.29 (4.41) | <0.001 |
| Type 2 diabetes, n (%) | 91 (41.0) | 7 (30.4) | 84 (42.2) | 0.277 |
| Kidney disease, n (%) | 55 (24.8) | 4 (17.4) | 51 (25.6) | 0.386 |
| Hypertension, n (%) | 139 (62.6) | 12 (52.2) | 127 (63.8) | 0.274 |
| Coronary heart disease, n (%) | 55 (24.8) | 7 (30.4) | 48 (24.1) | 0.507 |
| Arrhythmia, n (%) | 53 (23.9) | 8 (34.8) | 45 (22.6) | 0.195 |
| Medications, n (%) | | | | |
| Diuretics | 164 (73.9) | 18 (78.3) | 146 (73.4) | 0.613 |
| Beta-blockers | 111 (50.0) | 8 (34.8) | 103 (51.8) | 0.123 |
| ACEIs | 41 (18.5) | 6 (26.1) | 35 (17.6) | 0.392 |
| ARBs | 89 (40.1) | 7 (30.4) | 82 (41.2) | 0.318 |
| Negative affectivity score, mean (SD) | 6.53 (5.12) | 15.43 (3.49) | 5.50 (4.19) | <0.001 |
| Social inhibition score, mean (SD) | 6.05 (5.65) | 15.00 (4.44) | 5.02 (4.80) | <0.001 |
| Negative affectivity score ≥ 10, n (%) | 52 (23.4) | 23 (100) | 29 (14.6) | <0.001 |
| Social inhibition score ≥ 10, n (%) | 46 (20.7) | 23 (100) | 23 (11.6) | <0.001 |
| 6-month cardiac readmission, n (%) | 55 (24.8) | 10 (43.5) | 45 (22.6) | 0.028 |
| 18-month cardiac readmission, n (%) | 89 (40.1) | 13 (56.5) | 76 (38.2) | 0.089 |

ACEIs: Angiotensin-converting enzyme inhibitors; ARB: Angiotensin II receptor blockers; BMI: body mass index; BDI: Beck Depression Inventory; NYHA: New York Heart Association; SD: standard deviation.

^aBMI has 6 missing values.

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of 18-month cardiac readmission were 1.45 (95% CI = 1.08–1.93, *P* = 0.013) and 1.38 (95% CI = 1.03–1.85, *P* = 0.031) for Z-score transformed NA and SI, respectively. Furthermore, for the dichotomized scores, the risk of 6-month readmission was significantly higher in patients with either NA or SI (adjusted OR = 2.08, 95% CI = 1.01–4.31, *P* = 0.048) and adjusted OR = 2.15, 95% CI = 1.03–4.47, *P* = 0.041, respectively). The risk of 18-month readmission was significantly higher in patients with NA but marginally with SI (adjusted OR = 2.00, 95% CI = 1.04–3.85, *P* = 0.038) and adjusted OR = 1.97, 95% CI = 0.98–3.94, *P* = 0.056, respectively).

Discussion

Predicting readmission risk at the time of initial hospitalization in patients with heart failure can possibly provide better risk stratification, which allows for appropriate allocation of resources and targeted intervention. The present prospective study found that both Z-score

Table 2. Univariate logistic regression analyses of negative affectivity and social inhibition for 6-month and 18-month cardiac readmission in patients with heart failure (N = 222).

| Variable | mean (SD) or n (%) | | Odds ratio (95% CI) | P |
|----------|------------------------------|------------------------|---------------------|-------|
| | 6-month cardiac readmission | | | |
| | cardiac readmission | no cardiac readmission | | |
| | n = 55 (24.8%) | n = 167 (75.2%) | | |
| Z(NA) | 0.318 (1.070) | -0.108 (0.946) | 1.52 (1.12–2.06) | 0.007 |
| Z(SI) | 0.233 (0.940) | -0.072 (1.014) | 1.34 (1.00–1.79) | 0.052 |
| NA score | | | | |
| < 10 | 36 (65.5%) | 134 (80.2%) | 1.00 | |
| ≥ 10 | 19 (34.5%) | 33 (19.8%) | 2.14 (1.09–4.20) | 0.027 |
| SI score | | | | |
| < 10 | 38 (69.1%) | 138 (82.6%) | 1.00 | |
| ≥ 10 | 17 (30.9%) | 29 (17.4%) | 2.13 (1.06–4.28) | 0.034 |
| | 18-month cardiac readmission | | | |
| | cardiac readmission | no cardiac readmission | | |
| | n = 89 (40.1%) | n = 133 (59.9%) | | |
| Z(NA) | 0.215 (1.037) | -0.148 (0.939) | 1.45 (1.10–1.92) | 0.009 |
| Z(SI) | 0.144 (0.936) | -0.091 (1.038) | 1.26 (0.96–1.65) | 0.089 |
| NA score | | | | |
| < 10 | 61 (68.5%) | 109 (82.0%) | 1.00 | 0.022 |
| ≥ 10 | 28 (31.5%) | 24 (18.0%) | 2.08 (1.11–3.91) | |
| SI score | | | | |
| < 10 | 65 (73.0%) | 111 (83.5%) | 1.00 | 0.062 |
| ≥ 10 | 24 (27.0%) | 22 (16.5%) | 1.86 (0.97–3.58) | |

SD: standard deviation. NA: negative affectivity. SI: social inhibition. Z(NA): Z-score transformed negative affectivity score. Z(SI): Z-score transformed social inhibition score

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transformed NA and SI were significantly associated with an increased risk of 6-month and 18-month cardiac readmission. The risk ranged from 1.38 for 18-month cardiac readmission in Z-score transformed SI to 1.62 for 6-month cardiac readmission in Z-score transformed NA, adjusting for other potential confounders. Similar findings were obtained when NA and SI were analyzed as dichotomized scores, except SI was only marginally ($P = 0.056$) associated with 18-month cardiac readmission.

NA has previously been shown to be positively and strongly correlated with neuroticism of the Big Five personality traits, whereas SI was inversely and strongly correlated with extraversion. Moderate correlations were observed for extraversion with NA, neuroticism with SI, and conscientiousness and agreeableness for both NA and SI [23, 24]. In patients with acute coronary syndrome, a personality type characterized by higher neuroticism and lower extraversion, agreeableness, and conscientiousness was associated with a poorer outcome of depression [25]. Moreover, a systematic review and meta-analysis of prospective cohort studies indicated that anger and hostility were significantly associated with poor prognosis in patients with existing coronary heart disease. The association might be mediated through poor health behavior, such as poor diet, less physical activity, smoking, poor sleep, and lower treatment adherence [26]. These results are consistent with the findings in the present study that psychological factors, such as NA and SI, can play a role in the clinical outcome of patients with heart failure.

A number of potential pathophysiological pathways could be involved in the association of NA and SI on the increased risk of cardiac readmission. First, imbalance in the autonomic

Table 3. Multiple logistic regression analyses of negative affectivity and social inhibition for 6-month and 18-month cardiac readmission in patients with heart failure (N = 222).

| Variable | Adjusted odds ratio (95% CI) | P |
|---|------------------------------|-------|
| 6-month cardiac readmission | | |
| Z(NA) ^a | 1.62 (1.18–2.23) | 0.003 |
| Z(SI) ^b | 1.48 (1.08–2.02) | 0.014 |
| NA score (≥ 10 vs < 10) ^c | 2.08 (1.01–4.31) | 0.048 |
| SI score (≥ 10 vs < 10) ^a | 2.15 (1.03–4.47) | 0.041 |
| 18-month cardiac readmission | | |
| Z(NA) ^d | 1.45 (1.08–1.93) | 0.013 |
| Z(SI) ^e | 1.38 (1.03–1.85) | 0.031 |
| NA score (≥ 10 vs < 10) ^d | 2.00 (1.04–3.85) | 0.038 |
| SI score (≥ 10 vs < 10) ^e | 1.97 (0.98–3.94) | 0.056 |

NA: negative affectivity. SI: social inhibition. Z(NA): Z-score transformed negative affectivity score. Z(SI): Z-score transformed social inhibition score. Potential confounding variables evaluated during model development included: sex, age, body mass index, smoking, left ventricular ejection fraction, New York Heart Association functional classification, Beck Depression Inventory, type 2 diabetes, kidney disease, hypertension, coronary heart disease, arrhythmia, diuretics, beta-blockers, angiotensin-converting enzyme inhibitors, and angiotensin II receptor blockers.

^aVariables included in the adjusted model: sex, diuretics, and beta-blockers.

^bVariables included in the adjusted model: diuretics and beta-blockers.

^cVariables included in the adjusted model: sex, New York Heart Association functional classification, type 2 diabetes, hypertension, diuretics, and beta-blockers.

^dVariables included in the adjusted model: coronary heart disease, diuretics, and angiotensin-converting enzyme inhibitors.

^eVariables included in the adjusted model: coronary heart disease, diuretics, beta-blockers, and angiotensin-converting enzyme inhibitors.

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nervous system may play a role in the adverse cardiac events. A recent study in patients with coronary artery disease showed that NA was inversely correlated with standard deviation of all normal-to-normal intervals (SDNN) and total power of heart rate variability (HRV) [27]. In patients with heart failure, Type D personality was associated with an inadequate heart rate response [28], and there is strong evidence linking autonomic imbalance with heart failure [29].

Second, inflammation can play a pivotal role in the pathophysiology of heart failure [30]. A study on 228 patients with heart failure reported that Type D personality and change in self-reported physical health status over 18 months was significantly mediated by a number of inflammatory biomarkers [31]. Type D personality was shown to be associated with increased tumor necrosis factor-alpha (TNF-alpha) levels, which have been implicated in the pathogenesis of heart failure [32]. In addition, patients with Type D personality had significantly higher levels of the inflammation marker high-sensitivity C-reactive protein (hsCRP) compared with those with non-Type D personality [33], and a higher hsCRP was found to be an independent predictor of higher rates of readmission in patients with heart failure [34].

Third, endothelial function is a critical component in the systemic vasodilation in patients with heart failure [35]. A study on patients with heart failure found a significantly lower level of circulating CD34+/- kinase insert domain-containing receptor (KDR) + endothelial progenitor cells in patients with Type D personality, which might explain the association between impaired endothelial function in patients with Type D personality and heart failure [36]. In

addition, a recent prospective study on 180 patients with coronary artery disease reported that Type D personality could predict impaired endothelial function in men [37].

The results of this study should be interpreted in light of its limitations. First, the role of NA and SI components of Type D personality might vary for different types of heart failure, including right and left sided dysfunction, in isolation or together. Nevertheless, our sample size was not sufficient to allow for more refined stratification of the type of heart failure. Second, the study subjects were recruited from only two regional hospitals and may limit the generalizability of study findings. Third, the number of patients with Type D personality was only 23 and therefore, our findings should be considered as preliminary. Further studies involving a larger number of samples are needed to confirm our results. Fourth, while the mean score of the Beck Depression Inventory was observed to be significantly higher in patients with Type D personality in the present study and previous research has indicated that depression could exacerbate coexisting chronic heart failure and its clinical outcomes [38], severity of depression in our study participants did not appear to affect our findings. Nevertheless, the possible influence of other unmeasured variables, such as social support [39] on our findings was not evaluated and thus, the presence of potential confounding effects could not be completely ruled out.

In conclusion, the present prospective study in patients with heart failure suggested that NA and SI components of the Type D personality were significantly associated with a higher risk of cardiac readmission in both 6 months and 18 months after the initial hospitalization. If the above relationship could be reliably demonstrated in replication studies, the role for psychiatric treatment on cardiovascular outcomes should be considered and evaluated.

Supporting information

S1 Dataset. Dataset of the study.
(SAV)

Author Contributions

Conceptualization: Tin-Kwang Lin, Kai-Xun You, Chin-Lon Lin, Chia-Ying Weng, Malcolm Koo.

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References

1. Savarese G, Lund LH. Global public health burden of heart failure. *Card Fail Rev.* 2017; 3(1):7–11. <https://doi.org/10.15420/cfr.2016:25:2> PMID: 28785469; PubMed Central PMCID: PMC5494150.

2. Mosterd A, Hoes AW. Clinical epidemiology of heart failure. *Heart*. 2007; 93(9):1137–46. <https://doi.org/10.1136/hrt.2003.025270> PMID: 17699180; PubMed Central PMCID: PMCPMC1955040.
3. Go AS, Mozaffarian D, Roger VL, Benjamin EJ, Berry JD, Borden WB, et al. Heart disease and stroke statistics—2013 update: a report from the American Heart Association. *Circulation*. 2013; 127(1):e6–e245. <https://doi.org/10.1161/CIR.0b013e31828124ad> PMID: 23239837; PubMed Central PMCID: PMCPMC5408511.
4. McLaren DP, Jones R, Plotnik R, Zareba W, McIntosh S, Alexis J, et al. Prior hospital admission predicts thirty-day hospital readmission for heart failure patients. *Cardiol J*. 2016; 23(2):155–62. <https://doi.org/10.5603/CJ.a2016.0005> PMID: 26779968.
5. Desai AS, Stevenson LW. Rehospitalization for heart failure: predict or prevent? *Circulation*. 2012; 126(4):501–6. <https://doi.org/10.1161/CIRCULATIONAHA.112.125435> PMID: 22825412.
6. Kilgore M, Patel HK, Kielhorn A, Maya JF, Sharma P. Economic burden of hospitalizations of Medicare beneficiaries with heart failure. *Risk Manag Healthc Policy*. 2017; 10:63–70. <https://doi.org/10.2147/RMHP.S130341> PMID: 28546776; PubMed Central PMCID: PMCPMC5436769.
7. Chun S, Tu JV, Wijeyesundera HC, Austin PC, Wang X, Levy D, et al. Lifetime analysis of hospitalizations and survival of patients newly admitted with heart failure. *Circ Heart Fail*. 2012; 5(4):414–21. <https://doi.org/10.1161/CIRCHEARTFAILURE.111.964791> PMID: 22556322; PubMed Central PMCID: PMCPMC4700824.
8. Zaya M, Phan A, Schwarz ER. Predictors of re-hospitalization in patients with chronic heart failure. *World J Cardiol*. 2012; 4(2):23–30. <https://doi.org/10.4330/wjc.v4.i2.23> PMID: 22379534; PubMed Central PMCID: PMCPMC3289890.
9. Ross JS, Mulvey GK, Stauffer B, Patlolla V, Bernheim SM, Keenan PS, et al. Statistical models and patient predictors of readmission for heart failure: a systematic review. *Arch Intern Med*. 2008; 168(13):1371–86. <https://doi.org/10.1001/archinte.168.13.1371> PMID: 18625917.
10. Saito M, Negishi K, Marwick TH. Meta-analysis of risks for short-term readmission in patients with heart failure. *Am J Cardiol*. 2016; 117(4):626–32. <https://doi.org/10.1016/j.amjcard.2015.11.048> PMID: 26772444.
11. Aizawa H, Imai S, Fushimi K. Factors associated with 30-day readmission of patients with heart failure from a Japanese administrative database. *BMC Cardiovasc Disord*. 2015; 15:134. <https://doi.org/10.1186/s12872-015-0127-9> PMID: 26497394; PubMed Central PMCID: PMCPMC4619351.
12. Widdershoven J, Kessing D, Schiffer A, Denollet J, Kupper N. How are depression and type D personality associated with outcomes in chronic heart failure patients? *Curr Heart Fail Rep*. 2013; 10(3):244–53. <https://doi.org/10.1007/s11897-013-0139-7> PMID: 23661199.
13. Denollet J. DS14: standard assessment of negative affectivity, social inhibition, and Type D personality. *Psychosom Med*. 2005; 67(1):89–97. <https://doi.org/10.1097/01.psy.0000149256.81953.49> PMID: 15673629.
14. Kupper N, Denollet J. Type D personality as a prognostic factor in heart disease: assessment and mediating mechanisms. *J Pers Assess*. 2007; 89(3):265–76. <https://doi.org/10.1080/00223890701629797> PMID: 18001227.
15. Vukovic O, Tosevski DL, Jasovic-Gasic M, Damjanovic A, Zebic M, Britvic D, et al. Type D personality in patients with coronary artery disease. *Psychiatr Danub*. 2014; 26(1):46–51. PMID: 24608156.
16. Denollet J. Type D personality. A potential risk factor refined. *J Psychosom Res*. 2000; 49(4):255–66. PMID: 11119782.
17. Wu JR, Moser DK. Type D personality predicts poor medication adherence in patients with heart failure in the USA. *Int J Behav Med*. 2014; 21(5):833–42. <https://doi.org/10.1007/s12529-013-9366-2> PMID: 24198039; PubMed Central PMCID: PMCPMC4388325.
18. Cao X, Wang XH, Wong EM, Chow CK, Chair SY. Type D personality negatively associated with self-care in Chinese heart failure patients. *J Geriatr Cardiol*. 2016; 13(5):401–7. <https://doi.org/10.11909/j.issn.1671-5411.2016.05.011> PMID: 27594867; PubMed Central PMCID: PMCPMC4984567.
19. Weng CY, Denollet J, Lin CL, Lin TK, Wang WC, Lin JJ, et al. The validity of the Type D construct and its assessment in Taiwan. *BMC Psychiatry*. 2013; 13:46. <https://doi.org/10.1186/1471-244X-13-46> PMID: 23379902; PubMed Central PMCID: PMCPMC3598734.
20. Denollet J, Pedersen SS, Vrints CJ, Conraads VM. Predictive value of social inhibition and negative affectivity for cardiovascular events and mortality in patients with coronary artery disease: the type D personality construct. *Psychosom Med*. 2013; 75(9):873–81. <https://doi.org/10.1097/PSY.000000000000001> PMID: 24163388.
21. Dulfer K, Hazemeijer BA, Van Dijk MR, Van Geuns RJ, Daemen J, Van Domburg RT, et al. Prognostic value of type D personality for 10-year mortality and subjective health status in patients treated with

- percutaneous coronary intervention. *J Psychosom Res.* 2015; 79(3):214–21. <https://doi.org/10.1016/j.jpsychores.2015.05.014> PMID: 26084732.
22. Ferguson E, Williams L, O'Connor RC, Howard S, Hughes BM, Johnston DW, et al. A taxometric analysis of type-D personality. *Psychosom Med.* 2009; 71(9):981–6. <https://doi.org/10.1097/PSY.0b013e3181bd888b> PMID: 19834048.
 23. Fruty FD, Denollet J. Type D personality: A five-factor model perspective. *Psychology & Health.* 2010; 17(5):671–83. <https://doi.org/10.1080/08870440290025858>
 24. Horwood S, Anglim J, Tooley G. Type D personality and the Five-Factor Model: A facet-level analysis. *Personal Individ Differ.* 2015; 83:50–4. <https://doi.org/10.1016/j.paid.2015.03.041>
 25. Kim SY, Stewart R, Bae KY, Kim SW, Shin IS, Hong YJ, et al. Influences of the Big Five personality traits on the treatment response and longitudinal course of depression in patients with acute coronary syndrome: A randomised controlled trial. *J Affect Disord.* 2016; 203:38–45. <https://doi.org/10.1016/j.jad.2016.05.071> PMID: 27280961.
 26. Chida Y, Steptoe A. The association of anger and hostility with future coronary heart disease: a meta-analytic review of prospective evidence. *J Am Coll Cardiol.* 2009; 53(11):936–46. <https://doi.org/10.1016/j.jacc.2008.11.044> PMID: 19281923.
 27. Lin IM, Wang SY, Chu IH, Lu YH, Lee CS, Lin TH, et al. The association of Type D personality with heart rate variability and lipid profiles among patients with coronary artery disease. *Int J Behav Med.* 2017; 24(1):101–9. <https://doi.org/10.1007/s12529-016-9571-x> PMID: 27229521.
 28. Kupper N, Denollet J, Widdershoven J, Kop WJ. Type D personality is associated with low cardiovascular reactivity to acute mental stress in heart failure patients. *Int J Psychophysiol.* 2013; 90(1):44–9. <https://doi.org/10.1016/j.ijpsycho.2013.01.011> PMID: 23361112.
 29. Floras JS, Ponikowski P. The sympathetic/parasympathetic imbalance in heart failure with reduced ejection fraction. *Eur Heart J.* 2015; 36(30):1974–82b. <https://doi.org/10.1093/eurheartj/ehv087> PMID: 25975657; PubMed Central PMCID: PMC4528097.
 30. Kumar A, Paladugu B, Mensing J, Kumar A, Parrillo JE. Nitric oxide-dependent and -independent mechanisms are involved in TNF-alpha-induced depression of cardiac myocyte contractility. *Am J Physiol Regul Integr Comp Physiol.* 2007; 292(5):R1900–6. <https://doi.org/10.1152/ajpregu.00146.2006> PMID: 17234961.
 31. Mommersteeg PM, Pelle AJ, Ramakers C, Szabo BM, Denollet J, Kupper N. Type D personality and course of health status over 18 months in outpatients with heart failure: multiple mediating inflammatory biomarkers. *Brain Behav Immun.* 2012; 26(2):301–10. <https://doi.org/10.1016/j.bbi.2011.09.010> PMID: 21983280.
 32. Denollet J, Vrints CJ, Conraads VM. Comparing Type D personality and older age as correlates of tumor necrosis factor-alpha dysregulation in chronic heart failure. *Brain Behav Immun.* 2008; 22(5):736–43. <https://doi.org/10.1016/j.bbi.2007.10.015> PMID: 18068948.
 33. Son YJ, Song EK. The impact of type D personality and high-sensitivity C-reactive protein on health-related quality of life in patients with atrial fibrillation. *Eur J Cardiovasc Nurs.* 2012; 11(3):304–12. <https://doi.org/10.1016/j.ejcnurse.2011.04.004> PMID: 21601531.
 34. Alonso-Martinez JL, Llorente-Diez B, Echegaray-Agara M, Olaz-Preciado F, Urbieto-Echezarreta M, Gonzalez-Arencibia C. C-reactive protein as a predictor of improvement and readmission in heart failure. *Eur J Heart Fail.* 2002; 4(3):331–6. PMID: 12034159.
 35. Sharma R, Davidoff MN. Oxidative stress and endothelial dysfunction in heart failure. *Congest Heart Fail.* 2002; 8(3):165–72. PMID: 12045385.
 36. Van Craenenbroeck EM, Denollet J, Paelinck BP, Beckers P, Possemiers N, Hoymans VY, et al. Circulating CD34+/KDR+ endothelial progenitor cells are reduced in chronic heart failure patients as a function of Type D personality. *Clin Sci (Lond).* 2009; 117(4):165–72. <https://doi.org/10.1042/CS20080564> PMID: 19173675.
 37. Denollet J, van Felius RA, Lodder P, Mommersteeg PM, Goovaerts I, Possemiers N, et al. Predictive value of Type D personality for impaired endothelial function in patients with coronary artery disease. *Int J Cardiol.* 2018; 259:205–10. <https://doi.org/10.1016/j.ijcard.2018.02.064> PMID: 29477262.
 38. Liguori I, Russo G, Curcio F, Sasso G, Della-Morte D, Gargiulo G, et al. Depression and chronic heart failure in the elderly: an intriguing relationship. *J Geriatr Cardiol.* 2018; 15(6):451. <https://doi.org/10.11909/j.issn.1671-5411.2018.06.014> PMID: 30108618.
 39. Mazzella F, Cacciatori F, Galizia G, Della-Morte D, Rossetti M, Abbruzzese R, et al. <https://doi.org/10.1016/j.archger.2010.01.011> *Arch Gerontol Geriatr.* 2010; 51(3):323–8. PMID: 20153534.