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Childhood heart disease and parental emotional wellbeing: a predictive model to explain the perception of quality of life in children and adolescents

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Abstract

Background The number of people living with congenital heart disease (CHD) in 2017 was estimated to be 12 million, which was 19% higher than that in 1990. However, their death rate declined by 35%, emphasizing the importance of monitoring their quality of life due to its impact on several patient outcomes. The main objective of this study is to analyze how parents' psychosocial factors contribute to children's and adolescents' perceptions of their QoL, focusing on their medical condition. More specifically, we explore how parental psychological dimensions, such as anxiety and depression, are related to patients' health-related quality of life (HRQoL).

Methods We recruited 447 children aged 5 to 18 years with a CHD diagnosis and their parents (319 mothers and 229 fathers) from January to December 2018. Patients were referred to the Cardiology Department of "Bambino Gesù" Children's Hospital and participated in multidisciplinary standardized follow-up. Children and adolescents were submitted to a comprehensive evaluation by different physicians, including pediatric cardiologists, surgeons, and psychologists, at preset time frames. A series of standardized questionnaires were administered during psychological assessment.

Results The main findings show a negative correlation between mothers' anxiety and three patients' HRQoL subscales (Treatment II, Treatment anxiety, and Communication). Similarly, mothers' depression correlates negatively with other patients' HRQoL subscales (heart problems, symptoms, perceived physical appearance, cognitive problems, and communication). Fathers' anxiety and depression show negative correlations with only the subscale of Treatment II. More generally, the perceived quality of life of children and adolescents with CHD is influenced by their medical conditions as well as the parents' psychological dimensions.

Conclusions Our findings suggest that the caregivers of pediatric patients with CHD are more exposed to psychological problems of anxiety and depression, which affect the perceived quality of life of their children. Longitudinal research with a healthy control group is recommended to further consolidate this evidence.

Keywords Children with congenital heart disease (CHD), General and Health-related Quality of Life (PedsQoL), Patient report, Parents' anxiety, Parents' depression

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Introduction

The Global Burden of Diseases, Injuries, and Risk Factors Study estimates that 12 million people lived with congenital heart disease (CHD) in 2017. Data represent 19% more compared with the 1990s report. However, according to the same report, the 2017 death rate declined by 35% compared to the last detection date in 1990 [11, 35]. In this regard, medical and psychological care teams are particularly interested in monitoring patients' quality of life (QoL) due to its impact on several patients' outcomes. For example, previous findings have demonstrated the associations among high QoL scores, clinical improvement, and involvement in the care process (e.g., [42]). Moreover, patients' QoL may offer guidelines regarding treatment effectiveness that is useful for healthcare professionals' decisions. Not less importantly, patients' QoL self-assessment may offer valuable information regarding the impact of medical care and cardiac surgery on patients' QoL (e.g., [7, 26]). Considering the young age of patients with CHD, the well-being of their parents is expected to impact their quality of life as patients. Recent studies [45] have investigated demographic variables, including gender, age and heart disease, with no focus on parental mental health.

Other studies have investigated the discrepancy in parental and patient experiences on their quality of life [31].

The main objective of the current study is to analyze how parents' psychosocial factors contribute to children's and adolescents' perceptions of their QoL, focusing on their medical condition. Effectively, parents of CHD patients are more exposed to anxiety, stress, and depression linked to their children's exposure to death risk (e.g., [24, 36, 37]), resulting in the quality of care, future perspective regarding their children, and overall relationships inside the family. In this regard, a holistic and systemic perspective of CHD children's care requires a wider consideration of patients' and parents' psychosocial dimensions, which, in turn, significantly impact the positive results of medical team interventions. Using a multiperspective approach, this study aims to investigate how parents' well-being may affect young CHD patients' health-related QoL. More specifically, we are interested in analyzing how parents' psychological dimensions (i.e., anxiety and depression) are related to patients' health-related quality of life (HRQoL).

CHD young patients: the health-related quality of life

Health-related quality of life (HRQoL) is the patient's perception of how their health condition and medical treatment affect physical, social, and emotional functioning (Witt et al., 2019). The generic Pediatric Quality of Life (PedsQL) questionnaire [44] and the cardiac-specific module of the Health-Related Quality of Life (HRQoL) questionnaire (Urzak et al., 2013) are two different instruments used to assess the quality of life of children with congenital diseases. While the PedsQL questionnaire is a generic measure that assesses quality of life across physical, emotional, social, and school-related domains, the cardiac-specific module of the HRQoL questionnaire is a disease-specific measure focusing specifically on aspects related to the child's heart condition [41].

The cardiac-specific module of the HRQoL questionnaire investigates aspects of the child's health related to their CHD, such as the presence of cardiac symptoms, treatment adherence, and anxiety about treatment [18]. In their previous study, Amodeo et al. [3] found significant differences among six categories of young patients with CHD (i.e., aortopathies (Ao, patients with aortic disease from the aortic valvular lesion to the aortic arch anomalies, tetralogy of Fallot (ToF), univentricular heart (UVH), patients treated with Glenn or Fontan palliation according to the UVH physiology they had; right ventricular-pulmonary artery conduit (RV-PA conduit); transposition to the great arteries (TGA), and other congenital heart disease (oCHD)), which included a miscellaneous of diseases not considered above and the quality of life perceived by patients. Young patients with UVH showed the worst HRQoL levels referred to the cardiac-specific module overall. Considering the patient's age group, the authors have also found that the higher their age, the less their HRQoL levels showed regarding dimensions such as perceived physical appearance and cognitive status. In contrast, the inverse trend regarding communicative skills and cardiac management in the quality-of-life total dimension has been observed. Moreover, patients with mild CHD (i.e., without surgical repair) perceive higher HRQoL levels than patients with more complex CHD (i.e., with surgical repair). The negative impact of disease severity has been largely investigated, revealing similar trends in childhood age (e.g., [36, 42]) as well as in adolescence [34] (e.g., [24]).

These results constituted precious knowledge for the medical staff regarding CHD pediatric patients' adherence to treatment. However, although the findings partially confirm previous research [1, 25], they also open new questions about what factors may predict young patients' (s of their medical quality of life. Furthermore, no previous studies have analyzed the cardiac-specific module (Cardiac PedsQL) in an Italian sample of CHD children and adolescents concerning the predictive role of their parents' psychological dimensions on patients' QoL. A lack of information could weaken the understanding of which HRQoL domains appear less comfortable by considering sex, age, and disease severity in young patients [15, 43]. Age and gender, as well as disease

severity, can influence behavioral patterns and signals of perceived quality of life.

Parents' perceptions of CHD QoL and their caring experience

Parents' perceptions of their child's quality of life may significantly affect healthcare quality [36]. Their ability to care for a son with CHD has been proven to be affected by their own QoL on a mutually interconnected basis [43, 27]. Furthermore, the perception that children have of their HRQoL is affected by the burden of caregivers. For example, maternal mental health and worry have appeared to be the most important predictors of the psychosocial well-being of children with CHD, even more so than the illness severity itself [43, 27]. Some studies have suggested a higher risk of anxiety, depression, and stress for parents of children diagnosed with CHD compared with the general population (e.g., [46]). Other studies reported the development of a measure of caregiver burden for carers of children with chronic diseases, such as chronic kidney disease (e.g., [30]), the impact of severity of symptoms on quality of life in pediatric patients with atopic dermatitis [29], but not on the impact that caregivers' emotions and behaviors have on the quality of life of children with chronic illnesses.

A recent study [27] outlined how caregiver-related behaviors can accumulate, resulting in high stress and burden for caregivers. The stress process model conceptualizes that stressors may impact health and well-being [32]. This stress process model hypothesizes that poor health outcomes result from the stressors associated with the caregiving experience, including both primary stressors that derive directly from providing care (e.g., perceived caregiver burden) and secondary stressors that arise from these initial primary stressors (e.g., financial strains, family conflict) [22, 32].

A Systematic Review and Meta-Analysis on Health Outcomes of Parents of Children with Chronic Illness [8] suggested that parents of chronically ill children had greater anxiety and depression scores than parents of healthy children. In Cohn & C.'s study, mothers of children with congenital anomalies reported a greater mortality risk than a comparison, and another reported that these mothers experience an increased risk of cardiovascular disease. Some studies have focused on the association between parents' burden and the HRQOL of children with chronic illness [16]. We are interested in verifying whether parents' anxiety and depression levels impact their children's HRQoL.

Aims and hypotheses

Few studies have addressed the impact of parents' mental health on their CHD children's perception of quality of life. Using a multi-informant method involving parents and CHD children, the current study aims to investigate the predictive role of parents' anxiety and depression conditions in their children's health-related quality of life. First, we expect that children's and adolescents' perceptions of their HRQoL dimensions are negatively associated with mothers' and fathers' psychological dimensions (i.e., anxiety and depression symptoms). Finally, we investigated children's clinical characteristics (i.e., with and without heart problems and treatment and with or without treatment II) and sociodemographic variables (i.e., age and sex) as covariates with a generalized linear regression model (GLM).

Method

Participants and procedure

We recruited children aged 5 to 18 and their parents (when possible) into follow-up Day Hospital programs at the Cardiology Service of the Bambino Gesù Children's Hospital over one year (January 2018 – December 2018). Eligible criteria were as follows: i) children with congenital or acquired heart disease, summarized into 6 categories: 1. *Aortopathies* (Ao), which included all patients with aortic disease from the aortic valvular lesion to the aortic arch anomalies (i.e., aortic coarctation); 2. *Tetralogy of Fallot* (ToF), independent from the surgical approach they had had (transannular or infundibular patch); 3. *Univentricular heart* (UVH) included all patients treated with Glenn or Fontan palliation according to their UVH physiology; 4. *Right ventricular-pulmonary artery conduit* (RV-PA conduit) included all patients requiring a connection from RV to PA by conduit instead of the natural RV outflow tract; 5. *Transposition to the Great Artery* (TGA), including all patients with atrioventricular concordance and ventricular artery, treated with arterial switch operation; and 6. *Other congenital heart disease* (oCHD) included a miscellaneous of diseases not considered above; ii) both children and parents should be Italian literate and/or have good language knowledge. Exclusion criteria were as follows: i) patients with diagnosed genetic syndromes linked to cognitive impairment; ii) established and previously diagnosed cognitive impairment conditions; iii) other clinical conditions that do not allow the operations necessary to complete self-reported checklists (e.g., spastic paraparesis, sensory deficits); and iv) severe psychiatric disorders.

Participants received detailed information about the methods, aims, and voluntary nature of participation in the study. Written informed consent was obtained from each participant/patient and relative before enrollment. The study was conducted following the Helsinki Declaration. Ethical review committee

approval was obtained from the Bambino Gesù Children's Hospital ethical committee (retrospective observational study 2314 OPBG 2020).

A series of questionnaires were administered during patients' visits to the hospital, and sociodemographic characteristics were also collected.

Instruments

The PedsQL 3.0 Cardiac module-Italian version was administered to evaluate CHD patients' HRQoL in a self-administered form [5, 18, 41]. The Cardiac module is composed of six different domains: Heart problems and treatment (7 items),Treatment II (5 items—if the patient is on pharmacologic treatment), Perceived physical appearance (3 items),Treatment Anxiety (4 items),Cognitive problems (5 items) and Communication (3 items).

For self-reported versions, the questionnaire is divided by age: preschool children (5–7 years of age), school children (8–12 years of age), and adolescents (13–18 years of age). The parent-proxy report is categorized equally for children between 2 and 18 years old. Items are measured on a 5-point Likert scale from 0 = never to 4 = almost always. Scores are then transformed to a 0–100 scale where 0 = 100, 1 = 75, 2 = 50, 3 = 25 and 4 = 0. For children between 5 and 7 years old, the Likert scale is simplified to a 3-point scale: 0 = never, 1 = sometimes, and 2 = almost always [26, 36].

Two self-report checklists were administered to assess anxious-depressive symptoms in parents: the Generalized Anxiety Disorder Scale (GAD-7) [38] and the Patient Health Questionnaire (PHQ-9) [20, 21, 39, 47]. The Generalized Anxiety Disorder (GAD-7) checklist measures anxiety symptoms within seven items. Participants reported how often they had experienced symptoms in the past two weeks. The response options are "not at all," "several days," "more than half the days," and "nearly every day," scored on a Likert scale from 0 to 3, respectively. The threshold for symptom severity is *mild* from 5 to 9, *moderate* from 10 to 14, and *severe* from 15 to 21. The PHQ-9 is a short but highly effective self-assessment tool for depressive symptoms. Patients reported the presence of nine problems, including depression and interest decline, in the last 2 weeks on a 4-point Likert scale ranging from "nearly every day" (3 points) to "not at all" (0 points). The symptom severity scores are 5–9 for *Mild,* 10–14 for *Moderate*, and 15–27 for *Severe*.

Statistical analysis

Descriptive statistics were computed for demographic and clinical patient characteristics, PedsQL 3.0 Cardiac Module (self-report and proxy-report forms), as well as for the parent's anxiety-depression symptom measures and other related outcome variables. Scale internal consistency reliability was determined by computing Cronbach's coefficient α. Next, to test our first hypothesis, a series of Pearson correlation coefficients (with thresholds for medium and large correlation at 0.30 and 0.50, respectively) were carried out to determine the degree of associations and/or the presence of statistically significant differences among the target variables included in the present study. Categorical variables are presented as N and the percentage of the total study population. Means and standard deviations were used to describe continuous variables: anxiety and depression measures and quality of life. Next, a series of linear regression analyses via generalized linear regression (GLMs) was applied to the explanatory model to analyze whether children's perception of HRQoL could be predicted by demographic (age and sex) and clinical patient (surgery, CHD diagnosis, and pharmaceutical treatment) characteristic variables, as well as parents' depression and anxiety symptom severity levels. Each of the six HRQoL domains was a dependent variable since the cardiac module did not include a total score. For our purpose, and in line with previous studies (e.g., [9, 17]), parents' anxiety and depression scores were categorized into "mild", "moderate", and "severe" anxiety and depression levels (e.g., [4, 33]). Additionally, the age variable was included in the analysis as groups: 5–7 years, 8–12 years, and 13–18 years.

Predictors were selected according to the hypotheses and correlated with the outcome variable in a forward step. The presence of multivariate outliers was also checked and addressed before estimating the GLM. A Wald test (and its 95% confidence interval) based on robust estimates of the coefficients and covariance matrix were used to assess the models, and residual deviance as a goodness-of-fit statistic was applied to evaluate model overdispersion [23]. The model with the deviance/df ratio closest to the unit was retained as the most parsimonious model [23]. When a violation of the assumption of equidispersion is detected, a new model is estimated using the distribution form that best fits the data.

Results

Sample characteristics

All patients enrolled in our study were followed up in the cardiology outpatient clinic, whereas clinical examination, 12-lead ECG, and 2D echocardiography were performed at regular intervals according to their cardiac

conditions. Psychological tests and consultations were performed on the same day as the cardiac evaluation. Families were included if 1) patients aged between 2 and 18 years and 2) parents and patients could understand the questionnaires (*e.g.*, non-Italian speakers, severe neurodevelopmental disorder). Moreover, to avoid potential confounders, patients diagnosed with intellectual disability were excluded from the study. The analyses excluded fifty-two families: twenty-six because they were non-Italian speakers and sixteen due to their children's diagnosis of severe neurodevelopmental disorders and/or intellectual disabilities, while ten families refused to participate. Finally, the study encompassed all participants who met the inclusion criteria for a total sample comprising 447 children and adolescents and their parents.

The distribution per age range was quite homogeneous, with 78 patients (17.4%) who were 5 to 7 years old, 172 patients (38.5%) who were 8 to 12, and 197 (44.1%) who were 13 to 18 years old, with a slight predominance of males (58.2%).

Concerning the clinical and/or laboratory activity of the disease, 102 (22.8%) exhibited aortopathies, 60 (13.4%) exhibited transposition to the great artery, 60 (13.4%) had tetralogy of Fallot, 59 (13.2%) had univentricular heart, 48 (10.7%) exhibited right ventricular-pulmonary artery conduit, 2 (0.4%) had tetralogy of Fallot conduit, 2 (0.4%) had univentricular heart fontan, and 11 (24.8%) exhibited other congenital heart diseases. Furthermore, patients were distinguished into patients who received no surgery or medication (72 (16.1%) and patients who had undergone surgery (375 (83.9%)). Finally, among patients, 155 (34.7%) were subjected to pharmaceutical treatment, and 292 (65.3%) were not subjected to it.

Concerning the caregivers' characteristics, our sample comprised 319 mothers (Mage = 43.62 ± 5.98, range = 27–62) and 229 fathers (Mage = 46.76 ± 5.72, range = 30–62). The questionnaires were preferentially completed by mothers (71.36%), with 51% having attended secondary school, albeit incompletely, 23.7% having middle school and incomplete elementary education, and 25.3% having a degree or a specialization. Approximately half of the fathers (51.23%) answered the questionnaires. Among these, 46.2% had attended secondary school, albeit incompletely, 36.2% had middle or incomplete elementary education, and 17.6% had a degree or a specialization (Table 1).

Table 1 Sociodemographic and clinical characteristics of the sample ($N = 447$)

	N	%
Patients' age n (%)		
Young child (5–7)	78	17.4
Child (8–12)	172	38.5
Adolescent (13–18)	197	44.1
Patients' gender		
Male	260	58.2
Female	187	41.8
CHD diagnosis		
Ao	102	22.8
RV-PA conduit	48	10.7
TGA	60	13.4
ToF	60	13.4
ToF conduit	2	0.4
UVH	59	13.2
UVH fontan	2	0.4
oCHD	111	24.8
Missing	3	0.7
Surgery n (%)		
No surgery or Medication	72	16.1
Surgery	375	83.9
Pharmaceutical treatment		
Yes	155	34.7
Not	292	65.3
Parental age	M ± SD	Range
Mothers	43.62 ± 5.98	27–62
Fathers	46.76 ± 5.72	30–62

Ao Aortopathies, *M* mean, *n* no. of patients, *RV-PA conduit* Right ventricular-pulmonary artery conduit, *SD* standard deviation, *TGA* Transposition to the Great Artery, *ToF* Tetralogy of Fallot, *UVH* Univentricular heart, *oCHD* Other Congenital Heart disease

Descriptive statistics

The PedsQL™ 3.0 Cardiac Module scores of the patients' and caregivers' GAD-7 anxiety and PHQ-9 depression scores are detailed in Table 2. Descriptive statistics were displayed for the overall sample and each age group. Overall, mothers exhibited higher scores on anxiety and depression measures ($M_{GAD} = 5.35 \pm 4.10$, $M_{PHQ} = 4.19 \pm 3.73$) than fathers ($M_{GAD} = 3.90 \pm 3.72$, $M_{PHQ} = 3.05 \pm 2.83$).

A high percentage of missing values, close to 65–70%, was observed in the treatment II domain across the entire sample of patients and parents. This can be the result of a compilation waiver since patients who are not following drug treatment skipped these questions. Therefore, all analyses conducted considering this domain will be covered by a small number of patients compared to the total collected sample. Some missing values were also displayed in cognitive problems, communication domains, and GAD-7 and PHQ-9 measures.

Next, the data were cleaned and screened for out-of-range values and univariate/multivariate normality. Nineteen univariate outliers and two multivariate outliers were detected as assessed by the Mahalanobis distance test (above the cutoff $\chi^2 = 42.72$, $p < 0.001$) and thus

Table 2 Correlation between Pediatric Quality of Life Inventory™ 3.0 Cardiac Module domains and Parents' anxiety, and depression scores

Patients PedsQoL domains						
	Heart problems-symptoms	**Treatment II**	**Perceived physical Appearance**	**Treatment Anxiety**	**Cognitive problems**	**Communication**
Mothers						
Anxiety (GAD-7)	-0.066	-0.300**	-0.076	-0.133*	-0.036	-0.142**
Depression (PHQ-9)	-0.125*	-0.167	-0.152**	-0.085	-0.116*	-0.122*
Fathers						
Anxiety (GAD-7)	-0.092	-0.409**	-0.076	-0.069	0.008	0.015
Depression (PHQ-9)	-0.086	-0.234*	-0.098	-0.049	-0.097	-0.055

N = 426, missing pairwise

GAD-7 Generalized Anxiety Disorders, *PHQ-9* Patient Health Questionnaire

** $p < .01$

* $p < .05$

discharged from the analysis. The final database was composed of 426 cases. Item skewness and kurtosis values fall within the recommended thresholds [19], with kurtosis values ranging from ± 0.09 to ± 2.3 and skewness from ± 0.52 to ± 1.5 (see Table 1 supplementary table). Thus, all target study variables were deemed to be normally distributed. Cronbach's alpha reliability values for parents' anxiety were greater than 0.8 and close to.79 for the parents' depression measures. Acceptable alpha coefficient indices were found concerning Perceived physical appearance and Treatment anxiety, Heart problems and treatment, Treatment II, Cognitive problems, and Communication subscales of CHD's HRQoL. Likely, these low values seem to be due to missing data and the small sample size. However, our reliability results aligned with previous literature (e.g., [12, 18]).

Correlations

Preliminarily, Pearson's correlations were performed to test the degree of relationship between the patients' HRQoL domain scores and the mothers' and fathers' anxiety and depression (see Table 2).

According to the hypothesis, the patients' scores for subscales Treatment II, Treatment anxiety, and Communication exhibited low to moderate and significant negative correlation with the mother's anxiety, respectively: $r_{\text{Treatment II}} = -0.300$ ($p < 0.01$), $r_{\text{Treatment anxiety}} = -0.133$ ($p < 0.05$), $r_{\text{Communication}} = -0.142$ ($p < 0.01$). Mothers' depression scores were also found to correlate negatively with patients' heart problems-symptoms ($r = -0.125$, $p < 0.05$), perceived physical appearance ($r = -0.152$, $p < 0.01$), cognitive problems ($r = -0.116$, $p < 0.05$), and communication ($r = -0.122$, $p < 0.05$) scores. Fathers' anxiety and depression scores correlated negatively with patients' Treatment II symptom scores ($r = -0.409$, $p < 0.01$; $r = -0.234$, $p < 0.05$, respectively). No correlations were found with the remaining HRQoL domain scores.

Generalized linear models

A series of linear regressions were first run to predict the children's perception of HRQoL domains based on the demographic and clinical patient characteristics variables (i.e., CHD diagnosis and surgery condition) and parents' psychological experiences (depression and anxiety symptom severity levels).

All the models fit displayed an approximately equidispersion (deviance/df ~ 1), suggesting that the variance of the responses observed is close to what is assumed by the model (see Table 4), except for the cognitive problems domain model estimated. Far from overdispersion, which represents the most common violation of the assumption of equidispersion, underdispersion is less often the case. However, the violation of the equidispersion did not represent an issue in ordinary linear regression. The significant likelihood ratio chi-squares (see Table 4), a test of the overall model comparing this model to a model without any predictors, also provided evidence of improving each present model over the null model. For Treatment II, the likelihood ratio chi-square was close to the threshold levels of acceptability. In contrast, a nonsignificant likelihood ratio chi-square displayed by the cognitive problems HRQoL domain as the dependent variable confirmed its inadequacy to the data. Consequently, the results of this model will not be reviewed.

Table 3 contain model fit indices and the linear regression coefficients for each parameter of the predictor variables, along with their standard errors, Wald chi-square values, p values, and 95% confidence intervals for the coefficients. Among the independent variables in the equation, age and CHD diagnosis were

Table 3 Model fit indices for the GLMs models tested

	Heart problems and treatment			Treatment II			Perceived physical appearance			Treatment anxiety			Cognitive problems			Communication		
	Wald χ^2	*df*	*p*	Wald χ^2	*df*	*P*	Wald χ^2	*df*	*p*	Wald χ^2	*df*	*p*	Wald χ^2	*df*	*p*	Wald χ^2	*df*	*p*
Intercept	0.19	1	0.666	3.44	1	0.070	7.26	1	0.007	12.79	1	0.001	8.02	1	0.005	1.00	1	0.317
Age	14.78	2	0.001	15.66	2	0.001	11.01	2	0.004				5.52	2	0.063	8.42	2	0.015
CHD diagnosis	107.75	7	0.001				33.11	6	0.001	747.01	7	0.001	234.08	7	0.001	20.96	6	0.002
Surgery										7.87	1	0.005				6.70	1	0.010
Mothers' Anxiety				15.41	2	0.001				10.02	2	0.007						
Fathers' Anxiety							12.08	2	0.002									
Mothers' Depression	10.58	2	0.005							7.03	2	0.030	7.76	2	0.021			
Fathers' Depression	26.07	2	0.001	4.98	1	0.043										24.65	2	0.001
Deviance	147.37			41.53			150.49			171.42			160.18			163.19		
df	198			62			200			199			199			199		
deviance/df	0.744			0.670			0.752			0.861			0.805			0.820		
LRχ2	26.62			14.99			33.82			26.32			15.34			25.05		
df	13			5			11			12			11			12		
p	0.014			0.010			0.001			0.010			*0.168*			0.020		

Table 4 Parameter estimates for the GLM tested

	Heart problems and treatment							Treatment II							Perceived physical appearance						
	β	SE	Wald χ^2	*p*	Exp(b)	95% CI Exp(b)		β	SE	Wald χ^2	*p*	Exp(b)	95% CI Exp(b)		β	SE	Wald χ^2	*p*	Exp(b)	95% CI Exp(b)	
Intercept	-0.094	0.2386	0.155	0.694	0.910	0.570	1.453	0.833	0.3989	4.358	0.037	2.300	1.052	5.026	-0.223	0.3003	0.552	0.458	0.800	0.444	1.441
5–7 years	-0.645	0.1697	14.461	**0.001**	0.525	0.376	0.732	0.727	0.1869	15.122	**0.001**	2.068	1.434	2.983	0.050	0.1994	0.064	0.800	1.052	0.712	1.555
8–12 years	-0.164	0.1320	1.548	0.213	0.848	0.655	1.099	0.080	0.2241	0.127	0.722	1.083	0.698	1.680	0.386	0.1284	9.051	**0.003**	1.471	1.144	1.892
13–18 years	1 [Reference]							1 [Reference]							1 [Reference]						
Ao	0.083	0.1774	0.219	0.639	1.087	0.767	1.539								0.062	0.1657	0.139	0.709	1.064	0.769	1.472
RV-PA conduit	-0.123	0.2028	0.369	0.544	0.884	0.594	1.316								-0.167	0.2040	0.669	0.414	0.846	0.567	1.262
TGA	-0.061	0.1961	0.096	0.757	0.941	0.641	1.382								-0.224	0.1852	1.467	0.226	0.799	0.556	1.149
ToF	-0.206	0.2125	0.936	0.333	0.814	0.537	1.235								-0.340	0.2172	2.457	0.117	0.711	0.465	1.089
ToF conduit	-0.568	0.1866	9.253	**0.002**	0.567	0.393	0.817								0.605	0.1837	10.829	**0.001**	1.831	1.277	2.624
UVH	-0.481	0.2178	4.873	**0.027**	0.618	0.404	0.948								-0.765	0.2217	11.907	**0.001**	0.465	0.301	0.719
UVH fontan	0.252	0.1777	2.013	0.156	1.287	0.908	1.823								0.605	0.1837	10.829	**0.001**	1.831	1.277	2.624
oCHD	1 [Reference]														1 [Reference]						
Surgery																					
No surgery																					
Mothers' anxiety mild								0.056	0.1622	0.119	0.730	1.057	0.769	1.453							
Mothers' anxiety moderate								-1.201	0.3161	14.425	**0.001**	0.301	0.162	0.559							
Mothers' anxiety severe								1 [Reference]													
Fathers' anxiety mild															0.311	0.2441	1.622	0.203	1.365	0.846	2.202
Fathers' anxiety moderate															0.710	0.2640	7.241	**0.007**	2.035	1.213	3.414
Fathers' anxiety severe															1 [Reference]						
Mothers' depression mild	-0.282	0.1309	4.656	**0.031**	0.754	0.583	0.974														

Table 4 (continued)

Mothers' depression moderate	-0.677	0.2269	8.914	**0.003**	0.508	0.326	0.792																
Mothers' depression severe	1 [Reference]																						
Fathers' depression mild	0.807	0.1734	21.671	**0.001**	2.242	1.596	3.149	-0.803	0.3962	4.110	**0.026**	0.430	0.206	0.448									
Fathers' depression moderate	1.472	0.3742	15.471	**0.001**	4.358	2.093	9.074	1 [Reference]															
Fathers' depression severe	1 [Reference]																						
	Treatment anxiety							Cognitive problems							Communication								
	β	SE	Wald χ^2	*p*	Exp(b)	95% CI Exp(b)		β	SE	Wald χ^2	*p*	Exp(b)	95% CI Exp(b)		β	SE	Wald χ^2	*p*	Exp(b)	95% CI Exp(b)			
Intercept	-0.263	0.2611	1.017	0.313	0.769	0.461	1.282	-0.064	0.2407	0.071	0.790	0.938	0.585	1.503	-0.745	0.2517	8.753	0.003	0.475	0.290	0.778		
5–7 years								0.328	0.1647	3.968	0.046	1.388	1.005	1.917	-0.504	0.1844	7.463	**0.006**	0.604	0.421	0.867		
8–12 years								0.026	0.1502	0.030	0.863	1.026	0.765	1.378	-0.011	0.1331	0.007	0.932	0.989	0.762	1.283		
13–18 years								1 [Reference]							1 [Reference]								
Ao	-0.185	0.2077	0.796	0.372	0.831	0.553	1.248	-0.294	0.1592	3.401	0.065	0.746	0.546	1.019	-0.371	0.2061	3.244	0.072	0.690	0.461	1.033		
RV-PA conduit	-0.155	0.2492	0.387	0.534	0.856	0.525	1.396	-0.379	0.2134	3.149	0.076	0.685	0.451	1.040	-0.377	0.2405	2.456	0.117	0.686	0.428	1.099		
TGA	-0.191	0.2376	0.649	0.420	0.826	0.518	1.315	-0.465	0.1992	5.447	**0.020**	0.628	0.425	0.928	-0.457	0.2264	4.084	**0.043**	0.633	0.406	0.986		
ToF	-0.303	0.2384	1.616	0.204	0.739	0.463	1.179	-0.212	0.1968	1.157	0.282	0.809	0.550	1.190	-0.278	0.2339	1.411	0.235	0.757	0.479	1.198		
ToF conduit	-1.731	0.2172	63.466	**0.001**	0.177	0.116	0.271	1.081	0.2095	26.606	**0.001**	2.947	1.955	4.444	0.185	0.2295	0.652	0.419	1.204	0.768	1.887		
UVH	-0.294	0.2393	1.509	0.219	0.745	0.466	1.191	-0.372	0.2385	2.428	0.119	0.690	0.432	1.101	-0.608	0.2503	5.896	**0.015**	0.545	0.333	0.889		
UVH fontan	0.530	0.1693	9.809	**0.002**	1.699	1.219	2.368	0.650	0.1442	20.343	**0.001**	1.916	1.445	2.543	0.185	0.2295	0.652	0.419	1.204	0.768	1.887		
oCHD	1 [Reference]							1 [Reference]							1 [Reference]								
Surgery	0.720	0.2568	7.870	**0.005**	2.055	1.242	3.400								0.614	0.2372	6.701	**0.010**	1.848	1.161	2.941		
No surgery	1 [Reference]														1 [Reference]								
Mothers' anxiety mild	-1.314	0.4394	8.943	**0.003**	0.269	0.114	0.636																

Table 4 (continued)

Mothers' anxiety moderate	-1.460	0.4732	9.516	**0.002**	0.232	0.092	0.587												
Mothers' anxiety severe	1 [Reference]																		
Fathers' anxiety mild																			
Fathers' anxiety moderate																			
Fathers' anxiety severe																			
Mothers' depression mild	1.218	0.4596	7.018	**0.008**	3.379	1.373	8.317	0.430	0.1546	7.750	**0.005**	1.538	1.136	2.082					
Mothers' depression moderate	0.365	0.2371	2.364	0.124	1.440	0.905	2.292	0.272	0.3112	0.761	0.383	1.312	0.713	2.415					
Mothers' depression severe	1 [Reference]							1 [Reference]											
Fathers' depression mild															0.697	0.1810	14.817	**0.001**	2.007	1.408	2.861
Fathers' depression moderate															1.388	0.2862	23.521	**0.001**	4.006	2.286	7.019
Fathers' depression severe															1 [Reference]						

found to significantly predict heart problems and treatment ($\chi^2_{age}=14.78(2)$, $p=0.001$; $\chi^2_{diagnosis}=107.75(7)$, $p=0.001$), perceived physical appearance ($\chi^2_{age}=11.01(2)$, $p=0.004$; $\chi^2_{diagnosis}=33.11(6)$, $p=0.001$), and communication ($\chi^2_{age}=8.42(2)$, $p=0.015$; $\chi^2_{diagnosis}=20.96(6)$, $p=0.002$) domains of HRQoL. Furthermore, CHD diagnosis predicted the treatment anxiety domain ($\chi^2=747.01(7)$, $p=0.001$), CHD age predicted patients' treatment II scores ($\chi^2=15.66(2)$, $p=0.001$), and surgery was found to predict treatment anxiety ($\chi^2=7.87(1)$, $p=0.005$) and communication $\chi^2=6.70(1)$, $p=0.010$). Concerning parents' psychological dimensions, mothers' anxiety levels predicted the Treatment II ($\chi^2=15.41(2)$, $p=0.001$) and Treatment anxiety ($\chi^2=10.02(2)$, $p=0.007$) domains; likewise, their depression severity predicted Heart problems-symptoms ($\chi^2=10.58(2)$, $p=0.005$) and Treatment anxiety ($\chi^2=7.03(2)$, $p=0.030$). On the other hand, fathers' anxiety predicted the Perceived physical appearance domain ($\chi^2=12.08(2)$, $p=0.002$), and their depression severity levels predicted the Heart problems-symptoms ($\chi^2=26.07(2)$, $p=0.001$), Treatment II ($\chi^2=4.98(1)$, $p=0.043$), and Communication domains ($\chi^2=24.65(1)$, $p=0.001$). No significant effect was found for the sex variable.

Table 4 shows the estimated parameters for each CHD patient's perception of their HRQoL subscales.

Heart problems and treatment

CHD patients aged 5–7 years old showed a rate of 0.525 ($_{95\%CIExp(b)}$, 0.376–0.732) times lower (β = -0.645) than the 13–18 age group's rating score. Patients with *ToF conduit* and *UVH* diagnoses showed rates of 0.567 (95% CIExp(b), 0.393–0.817) and 0.618 (95% CIExp(b), 0.404–0.948) times lower (β = -0.568 and -0.481) than the other CHD diagnoses' heart problems and treatment rating scores, respectively. Furthermore, CHD patients with mothers' mild and moderate depression levels showed rates of 0.754 ($_{95\%CIExp(b)}$, 0.583–0.974) and 0.508 ($_{95\%CIExp(b)}$ 0.326–0.792) times lower (β = -0.282 and -0.677), respectively, than those with mothers' severe depression levels. In contrast, with fathers' mild and moderate depression levels, CHD rates were 2.242 ($_{95\%CIExp(b)}$, 1.596–3.149) and 4.358 ($_{95\%CIExp(b)}$ 2.093–9.074) times higher (β = —0.807 and 1.472) than those with fathers' severe depression levels, respectively.

Treatment II

CHD patients aged 5–7 years old showed a rate of 2.068 ($_{95\%CIExp(b)}$, 1.434–2.983) times more (β = 0.727) than the 13–18 age group's rating scores. Concerning mothers' anxiety levels, CHD rates were 0.301 ($_{95\%CIExp(b)}$, 0.162–0.559) times lower (β = -1.21) with mothers' moderate anxiety levels than with mothers' severe anxiety levels. Finally, CHD scores were 0.430 ($_{95\%CIExp(b)}$, 0.206–0.448) times lower (β = —0.803) with fathers' mild depression than with fathers' moderate depression levels. No fathers with severe depression scores were observed in the present model.

Perceived physical appearance

CHD patients aged 8–12 years old showed a rate of 1,471 ($_{95\%CIExp(b)}$, 1.144–1.892) times higher (β = 0.386) than the 13–18 age group's rating scores. Likewise, CHD patients with a ToF conduit diagnosis showed a rate of 1.831 ($_{95\%CIExp(b)}$ 1.277–2.624) times higher than (β = 0.605) other CHD diagnosis rating scores. In contrast, patients with UVH diagnosis had a 0.465 ($_{95\%CIExp(b)}$ 0.301–0.719) times lower (β = -0.765) probability of displaying perceived physical appearance than the reference group. Finally, CHD patients with fathers' moderate anxiety levels showed a subscale rate of 2,035 (95% CIExp(b), 1.213–3.414) times more (β = 0.710) than those with fathers' severe anxiety levels.

Treatment anxiety

CHD patients with ToF conduit diagnosis showed a rate of 0.177 ($_{95\%CIExp(b)}$ 0.116–0.271) times lower (β = -1.731) than other CHD diagnosis rating scores. On the other hand, patients with UVH Fontan diagnosis were 1.699 ($_{95\%CIExp(b)}$ 1.219–2.368) times more likely to perceive a good health-related quality of life compared to the reference group (β = 0.530). Finally, those who have undergone surgical treatment have a 2.055 ($_{95\%CIExp(b)}$ 1.242–3.400) times higher probability of perceiving a better quality of health-related quality of life on the treatment anxiety subscale (β = 0.720) than those who have not undergone surgery/medications. Concerning mothers' anxiety levels, CHD patients with mothers' mild and moderate anxiety levels showed treatment anxiety rates of 0.269 ($_{95\%CIExp(b)}$ 0.114–0.636) and 0.232 ($_{95\%CIExp(b)}$ 0.092–0.587) times lower (β = -1.314 and -1.460), respectively, than patients with CHD with mothers' severe anxiety levels. In contrast, patients with mothers' mild depression levels rated their treatment anxiety dimension 3.379 ($_{95\%CIExp(b)}$ 1.373–8.317) times higher (β = 1.218) than CHD patients with mothers' severe depression levels.

Communication

Patients with CHD aged 5–7 years old showed a subscale rate of 0.604 ($_{95\%CIExp(b)}$, 0.421–0.867) times lower (β = -0.504) than the 13–18 age group's rating scores. Likewise, patients with TGA and UVH diagnoses showed rating scores of 0.633 ($_{95\%CIExp(b)}$, 0.406–0.986) and 0.545 ($_{95\%CIExp(b)}$ 0.333–0.889) times lower (β = -0.457 and -0.608), respectively, than the other CHD diagnoses' rating scores. Finally, patients with a surgical treatment

showed a subscale rate of 1.848 ($_{95\%CIExp(b)}$ 1.161–2.941) times higher probability of perceiving a better health-related quality of life referred to the Communication subscale (β = 0.614) compared to those without surgical treatment. Similarly, patients with fathers' mild and moderate depression levels showed rating scores of 2.007 ($_{95\%CIExp(b)}$, 1.408–2.861) and 4.006 ($_{95\%CIExp(b)}$ 2.286–7.019) times higher (β = 0.697 and 1.388) than patients with CHDs' rating scores with fathers' severe depression levels.

Discussion

The main aims of the present study were to investigate the perceived quality of life of pediatric patients with CHD by analyzing the correlations with the psychological aspects of parents' anxiety and depression as well as with their medical characteristics. More specifically, we first investigated the correlations between patients with CHD characteristics (i.e., age and medical conditions) and their HRQoL self-reported, on the one hand, and their parents' psychological dimensions (i.e., anxiety and depression levels), on the other hand. Second, we expected that mothers' anxiety and depression symptoms would affect their children's perception of HRQOL with a higher predictive power than fathers' psychological experiences. To better understand the predictive role of parents' psychological conditions, three anxiety and depressive levels were investigated (i.e., moderate, mild, and severe levels). The findings confirm our hypotheses: the mother's anxiety negatively correlates with three patients' HRQoL subscales (i.e., Treatment II, Treatment anxiety, and Communication).

Similarly, mothers' depression correlates negatively with other patients' HRQoL subscales (i.e., heart problems, symptoms, perceived physical appearance, cognitive problems, and communication). Considering fathers' anxiety and depression, our results show negative correlations with only the subscale of Treatment II. Then, there were interesting correlations between the subdimensions of the self-reported child QoL and their age at the time of measurement. The perceived quality of life of children and adolescents with CHD is influenced by their medical conditions as well as parents' psychological dimensions. More specifically, the predictive hypothesis has been evaluated with a GLM showing a significant predictive role of young patients' characteristics on their HRQoL self-assessment. Children's perception of heart problems and treatment, perceived physical appearance, and communication are affected by their age and CHD diagnoses.

Furthermore, CHD diagnosis predicts patients' perception of treatment anxiety, while their age predicts treatment II. Finally, surgery was found to predict treatment anxiety and communication. Concerning the predictive role of parents' psychological dimensions (i.e., anxiety and depression levels), our results show that mothers' anxiety levels predict young patients with CHD's Self-assessment of Treatment II and Treatment anxiety domains of HRQoL. At the same time, mothers' depression severity predicted patients with CHD's self-perception of heart symptoms and treatment anxiety. On the other hand, fathers' anxiety levels predict young patients with CHD's self-perception of the quality of life concerning the Perceived physical appearance, Heart symptoms, Treatment II, and Communication domains.

The positive and negative predictive role of patient age, medical conditions, and parents' well-being

The following section focused on the HRQoL subscales, discussing separately the main negative and positive predictive roles of each independent variable.

The six HRQoL subscales were analyzed as dependent variables in six distinctive predictive models. Only the cognitive problems subscale will not be analyzed as specified in the Statistical Analysis section.

The predictive model of *the heart problem and treatment* dimension shows a negative effect of the following independent variables: being a 5- to 7-year-old patient with a *ToF conduit* or *UVH* diagnosis, with mothers suffering from mild and moderate depression levels. Some studies [6, 13] have observed that mothers of children treated at an intensive care unit due to congenital heart disease are at increased risk for the development of depression and difficulties in different aspects of postpartum bonding.

Furthermore, in another article [10], mothers unresolved to the diagnosis had higher rates of posttraumatic stress than those resolved to the diagnosis. Mothers of infants with a prenatal diagnosis of CHD reported significantly lower rates of life stress despite higher severity of heart defects.

The predictive model of the *Treatment II* HRQoL dimension shows a negative effect of the following independent variables: being a patient with a mother affected by a moderate anxiety level and a father's mild depression level. In a recent article [28], parents of children with hypoplastic left heart syndrome reported anxiety, QOL and family resources worse than the general population,33% reported family dysfunction. There were no meaningful differences between reports from mothers and fathers. Parental perception of better child health was associated with better family management of the condition.

The predictive model of *Perceived physical appearance* subscale shows that the following independent variables can negatively impact CHD patients' perception: being a patient with a UVH diagnosis. There is no study on body

and scar acceptance and chronic heart disease as UVH diagnosis. It might be interesting to study this aspect in the future.

The fourth subscale of the HRQoL evaluates patients' perception of their *treatment anxiety*. Our findings show the negative and predictive impact of the following independent variables: being a patient with a ToF conduit diagnosis and having a mother suffering from mild and moderate anxiety. In a recent article, the levels of stress and anxiety suffered by parents of children with congenital heart disease during their children's admission for cardiac surgery may be higher than those suffered by other parents who go through the same experience [2].

Finally, for the *Communication* subscale HRQoL dimension, patients' self-reports are negatively predicted by the following independent variables: being a patient of 5 to 7 years with TGA or UVH diagnosis. Although survival improved after the introduction of Fontan surgery in patients with UVH during the last 20 years, problems related to communication between patients and medical and surgical staff remain that affect the quality of life and survival.

Concerning the positive predictive role, our findings shed interesting light on the effect of surgical treatment. In other words, having a surgical treatment positively predicts their self-evaluation of *treatment anxiety* and *communication* HRQoL dimensions. This means that medical and surgical advances increase the trust and confidence of patients and their family in medical staff by improving communication and reducing perceived anxiety. Surgical progress should be supported by personalized medicine staff attentive to specialized and integrated care with dedicated units.

As described in Table 1 supplementary, the mothers' anxiety and depression (mean 5.22 and 4.05) cannot be defined with clinical connotations in the total group, but it is worse than those fathers (mean 3.92 and 3.05) and is probably linked to the role of care played by mothers as caregivers in the chronic disease of their children. Research shows that maternal roles are deeply embedded in cultural norms, leading to greater emotional and practical caregiving responsibilities. This is often linked to higher levels of anxiety and depression in mothers compared to fathers, as highlighted by recent studies in caregiving psychology [40]. Moreover, paternal involvement, while typically less emphasized, has been associated with unique stressors. Fathers who engage deeply in caregiving can experience increased psychological distress due to deviations from traditional caregiving norms, highlighting the need for supportive systems that address these challenges [14].

Mothers' levels of anxiety and depression could also explain the lower scores on parent proxy reports to the Pediatric Quality of Life Inventory 3.0 The cardiac module of mothers compared to children and fathers is described in Table 2. However, the variable nature of the evidence gathered to date suggests that caution should be exercised when interpreting findings on children's perceptions of HRQoL domains and the psychological health of caregivers.

Finally, the predictive model that best explained the perception of the QoL in children and adolescents with CHD comprised seven factors: age of patients, CHD diagnosis, surgery, mothers' anxiety, fathers' anxiety, mothers' depression, and fathers' depression. Each of these categorical factors was measured to predict the children's perception of HRQoL domains. The predictive model highlighted that patients' HRQoL was influenced by the child's age and the severity of childhood heart disease in five of the six QoL subdimensions. Mothers' and fathers' depression influenced half of the QoL dimensions, and mothers' and fathers' anxiety influenced 1/3 of the QoL dimensions.

Conclusion

Our findings suggest a need for targeted interventions, such as CHD, linked to negative health and well-being outcomes. Some studies have found that caregiving can be linked to negative outcomes – primarily psychological processes – such [8] as anxiety and depression in mothers.

The presence of correlations between the self-perceived QoL of the young CHD patients in our study and their age provides key indications for future research on children and adolescents with this and other chronic diseases.

In general, our data suggest that the caregivers of pediatric patients with CHD are more exposed to psychological problems of anxiety and depression and affect the perceived quality of life of their children [3]. Our study contributed to the growing body of knowledge on QoL in CHD, emphasizing the need for these families to receive support from multidisciplinary standardized care, including psychological consultations and support for caregivers.

Nonetheless, the study's cross-sectional design limits causal interpretations. Follow-up longitudinal research, incorporating a healthy control group, is strongly recommended to consolidate these findings and further clarify the observed relationships. Future studies should also explore the long-term psychological and HRQoL outcomes for both patients and caregivers to guide more effective interventions.

Supplementary Information

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Supplementary Material 1.

Authors' contributions

T.G.C, C.C. and C.F. conceptualized the manuscript; L.C., M.B., T.G.C. and C.F. wrote the methodology; L.C., M.B. and C.F. made the formal analysis; T.G.C., G.A., C.C. lead the investigation; T.G.C., C.C., G.A. were in charge og data curation; T.G.C., C.F., C.C., L.C. made original draft preparation; all authors wrote, reviewed, edited and aproved the final version of the manuscript.

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Data availability

The data that supports the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Declarations

Ethics approval and consent to participate

Ethical review committee approval was obtained from the Bambino Gesù Children's Hospital ethical committee (retrospective observational study 2314 OPBG 2020).

Competing interests

The authors declare no competing interests.

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