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Anxiety, depression and quality of life in chronic obstructive pulmonary disease patients and caregivers: an actor–partner interdependence model analysis

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Abstract

Purpose We aimed to assess the influence of anxiety and depression on the physical and mental quality of life (QoL) in patient with chronic obstructive pulmonary disease (COPD) and caregiver dyads, detect the simultaneous effect of anxiety and depression of each partner on the other's QoL and determine the dyadic patterns.

Methods A cross-sectional descriptive design was used. The actor–partner interdependence model estimated by structural equation modeling was used for the dyadic analysis. Patient Health Questionnaire-9 (PHQ-9), Generalized Anxiety Disorder-7 (GAD-7) and 12-Item Short-Form Health Survey (SF-12) were used to measure depression, anxiety and QoL, respectively.

Results Eighty COPD dyads were enrolled in the study. Patients presented higher depression symptoms and poorer physical and mental QoL than their caregivers, whereas comparable levels of anxiety were found in patients and caregivers. The model exploring the effects of depression and anxiety on mental QoL found that patients' depressive symptoms negatively influence their mental QoL, and caregivers' anxiety and depression symptoms negatively impact their mental QoL. The model exploring the effects of anxiety and depression on physical QoL detected one statistically significant actor effect with patients' depressive symptoms negatively influencing their physical QoL, and two partner effects with caregivers' anxiety worsening patients' physical QoL and caregivers' depression improving patients' physical QoL.

Conclusions The results suggest that caregivers' psychological distress influences caregivers' mental QoL and patients' physical QoL. Therefore, health-care professionals should assess and treat anxiety and depression in both members of the COPD dyad to improve their QoL.

Keywords COPD · Quality of life · Anxiety · Depression · Dyadic analysis · SEM

Introduction

Chronic obstructive pulmonary disease (COPD) is a group of progressive lung conditions characterized by respiratory symptoms, such as breathlessness, sputum and cough, accompanied by psychological manifestations, such as

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depression and anxiety [1]. In fact, people with COPD present symptoms of depression and anxiety more frequently than the general population of the same age [2–4] and than people suffering from other chronic illnesses [4], with a mean prevalence of 40% for depression (range 8–80%) and 36% for anxiety (range 6–74%) [5]. Depression and anxiety are associated with COPD exacerbations [6], increased risk of hospitalization and mortality [4, 7, 8] and reduction in physical and mental quality of life (QoL) [9, 10].

With the progression of the disease severity, people with COPD become more dependent for their care on family members or friends, known as informal caregivers or carers [11]. The burden of taking care daily of a person with COPD leads caregivers to develop symptoms of anxiety, depression [12, 13] and poor health outcomes [14]. In caregivers, the prevalence of depressive symptoms is 51% [15] and of anxiety 64% [16]. Similar to people with COPD, caregivers' anxiety and depression influence negatively their QoL [17, 18].

Several studies have shown a correlation between general well-being and anxiety [17] and depression symptoms [17, 19] in COPD patients and their caregivers; however, these studies analyzed the psychological manifestations from an individual level of analysis, without considering the possible reciprocal influence of patients and caregivers' psychological status on each other (dyadic level). According to the interdependence theory [20], in close relationships interacting people influence each other's emotions, behaviors, cognition and outcomes [21]. Partners are psychologically dependent on one another during distressing events, and behaviors of one member can affect the health state of the other [22]. Only a few studies have been carried out, considering the COPD patient–caregiver dyad as a unit of analysis and controlling for the non-independence within dyads. For example, Vaske et al. [23] analyzed dyadic coping and its effects on QoL, and Badr et al. [19] examined the predictors of depression in COPD patient–caregiver dyads.

Dyadic studies conducted with caregivers and patients with heart failure [24], stroke [25] or cancer [26] showed the influence of depression and anxiety on patient's QoL, as well as on the caregiver's QoL. Understanding the reciprocal influence of psychological distress in COPD patients and their caregivers can allow for more effective treatment of the patients' emotional distress and, consequently, improve their QoL.

To our knowledge, no study so far has analyzed the relationship between anxiety, depression and QoL using the COPD patient–caregiver dyad as unit of analysis. Therefore, we conducted a study aimed at assessing the influence of anxiety and depression on physical and mental QoL of patients and caregivers, detecting the effect of anxiety and depression of each partner on the other's QoL and determining dyadic patterns of the influence of anxiety and depression on QoL. We hypothesized that COPD patients and caregivers would present similar levels of anxiety and depression, and that greater anxiety and depression symptoms would be associated with poorer mental and physical QoL in both patients and caregivers. Furthermore, we hypothesized that anxiety and depression would influence negatively the person's own and the partner's mental and physical QoL.

Methods

Research design

The study was a secondary analysis of data collected from COPD patients and their caregivers enrolled in an observational longitudinal study on self-care in COPD dyads. Cross-sectional data collected at time 0 were considered for this study.

Population and sample

COPD dyads were recruited in two outpatient pneumological clinics in Rome, Italy. Assistant researchers asked eligible patients and respective caregivers, who consecutively presented at outpatient clinics in the days dedicated to the ambulatory visits, if they were willing to participate in the study. The caregiver was defined as a member of the family (i.e., wife/husband, son/daughter or other relative) or an unpaid significant other (i.e., friend) who was mainly responsible for the care of the COPD patient. The enrollment was conducted in 11 months from November 2016 to October 2017.

Inclusion/exclusion criteria

Patients aged 18 and over, with a diagnosis of COPD at any disease stage, were included in the study. The caregiver, aged 18 and over, had to be identified by the patient as the primary informal care provider. Participants should have a good comprehension of Italian. The criteria for exclusion were the presence of cognitive impairment, detected from medical records for the patient or reported by the patient for the caregiver, a neoplastic diagnosis in patients or caregivers and refusal to sign the informed consent from one of the members of the dyad.

Data collection

The person with COPD and the caregiver that agreed to participate in the research received the questionnaires, with indications to complete them separately without discussing the answers with each other. They could choose to complete

the questionnaires either after or before the planned visit. In case of impairment in vision or in writing, or for clarifications, the participants were supported by trained research assistants.

Measures

The following instruments were administered to both patient and caregiver

Patient Health Questionnaire-9 (PHQ-9) [27]

This is a self-reported instrument, which assesses depression symptoms through nine items. Answers are reported on a 4-point Likert scale, scoring from 0 (symptoms not present) to 3 (symptoms present nearly every day), providing a possible score of 0 to 27. Scores of 5, 10, 15 and 20 represent the cutoff points for mild, moderate, moderately severe and severe depression, respectively. PHQ-9 showed Cronbach's alpha coefficients from 0.86 to 0.89, test–retest of 0.84, sensitivity of 0.88 and specificity of 0.88 for cutoff point ≥ 10 [28]. PHQ-9 has been used in previous studies on people with COPD and their caregivers [19]. For our study, we used the validated Italian version [29], freely downloadable on the PHQ Web site (http://www.phqscreeners.com). In our sample, the instrument presented a Cronbach's alpha coefficient of 0.84 in patients and 0.82 in caregivers.

Generalized Anxiety Disorder-7 (GAD-7) [30]

This is a widely used instrument that measures common anxiety disorders trough seven items, each of which is scored from 0 (symptoms not present) to 3 (symptoms present nearly every day), providing a score of 0 to 21. Scores of 5, 10 and 15 represent cutoff points for mild, moderate and severe anxiety, respectively. Sensitivity was 0.89 and specificity 0.82 for a cutoff ≥ 10, with a Cronbach's alpha coefficient of 0.89 [28]. It has been used on COPD patients [31]. In the present study, the Cronbach's alpha coefficient was 0.88 in patients and 0.91 in caregivers. The Italian version downloadable on the PHQ Web site was used.

12-Item Short-Form Health Survey (SF-12v2) [32]

This generic health-related QoL instrument was selected because it enabled the assessment of QoL in both patients and caregivers. It provides two separate measurements for the physical component (PCS) and mental component (MCS) of QoL. The score ranges from 0 to 100 for each subscale, with higher scores indicating better QoL. The SF-12 presented a Cronbach's alpha coefficient of 0.84 for the PCS and 0.70 for the MCS [33]. The SF-12 was validated in the Italian population [34] and was used in previous studies on COPD [35, 36].

Comorbidity index

To assess comorbidity in patients and caregivers, a list of 33 common chronic diseases was created by the researchers, based on the list of chronic conditions that are included in health coverage in Italy. Participants were asked to self-report which of the listed diseases they suffered from.

Furthermore, general sociodemographic data were collected, including gender, age, living condition (alone or with the family), education, employment and referred financial status (from less than needed, sufficient and more than needed income).

The following instruments, which are broadly used to measure the disease severity and the impact of COPD on health were administered to the COPD patients only.

Modified Medical Research Council dyspnea scale (mMRC) [37]

This scale measures the impact of dyspnea on patients' daily activities on a scale from 0 (no limitation in daily activities) to 4 (very severe limitation).

ABCD assessment tool [1]

The Global Initiative for Obstructive Lung Disease (GOLD) document suggests classifying the level of disease severity as A, B, C or D, based on the spirometric value of forced expiratory volume in 1 second (FEV_1), magnitude of dyspnea evaluated by mMRC or its impact on health status assessed by the COPD Assessment Test (CAT^{TM}) [38, 39] and the number of exacerbations or hospitalizations. The FEV_1 was obtained from the patients' medical records, and information on previous hospitalizations and exacerbations were collected by interviewing the patients.

Caregiving characteristics

We investigated the type of relationship with the patient (i.e., spouse/partner, son/daughter), further support from another caregiver and the number of hours of caregiving per week by interviewing caregivers.

Data analysis

Descriptive statistics (such as means, standard deviations, frequency, percentages) were computed to describe demographic and clinical characteristics in patients and caregivers. Pearson's product-moment correlation coefficients were calculated to test the non-independence of the variables;

effect sizes of 0.10, 0.30 and 0.50 were considered to be small, medium and large, respectively [40]. Paired *t* test or chi square (χ^2) was computed to examine differences among people with COPD and caregivers' variables for continuous or categorical variable, respectively. The presence of missing data was evaluated, and no missing data were recorded.

The actor–partner interdependence model (APIM) was used to analyze the dyadic data because it is a method that considers the non-independence of the data [21]. In fact, APIM permits the measurement of the impact of the independent variable of a member of a dyad on his/her own dependent variable (actor effect) and the impact of his/her independent variable on the dependent variable of the other member of the dyad (partner effect). The graphical representation of APIM is illustrated in Fig. 1 with a detailed explanation. In our study, anxiety and depression were considered the independent variables, and MCS and PCS the dependent variables. APIM has been widely applied in social and psychological sciences; recently, it has also been used to study patient and caregiver dyads in heart failure [24], stroke [25] and cancer [26].

To assess the dyadic patterns, Kenny and Ledermann suggested the estimation of the parameter *k*, which quantitatively synthesizes the dyad members' respective influence on the dependent variable, expressed as the ratio of the partner (*p*) to the actor (*a*) effect [41]. Four dyadic patterns are identifiable based on the statistical significance of the effects: the couple-oriented ($a=p$, $k=1$), in which a person's outcome is equally influenced by his/her independent variable and by the independent variable of the partner; the contrast pattern ($a+p=0$, $k=-1$), in which a person's outcome is influenced positively by his/her independent variable and negatively by that of his/her partner; the actor-only ($a\neq 0$ $p=0$, $k=0$) in which the independent variable affects only the actor's and not the partner's outcome; and the partner-only ($a=0$ $p\neq 0$, $k=0$ with *k* expressed as the ratio of the actor (*a*) to the partner (*p*) effect), in which the member's independent variable influences only the partner's outcome [42].

Structural equation modeling (SEM) with maximum likelihood (ML) estimation [43] was used to estimate APIM and *k* parameters. SEM is recommended for APIM for distinguishable dyads, such as those in our study in which dyad members were distinguished by their roles, care receiver and caregiver, because it permits us to directly estimate the model, to impose equality and constraints on parameters of the model [44], and to compute the *k* parameters. The web application APIM_SEM (available at https://apimsem.ugent.be/shiny/apim_sem/) was used because it enables direct performance of the statistical analyses for APIM and the production of figures representing the path diagrams [45].

Test of complete indistinguishability

To confirm empirically the distinguishability between the members of the dyads based on their role, the test of complete indistinguishability was performed comparing the

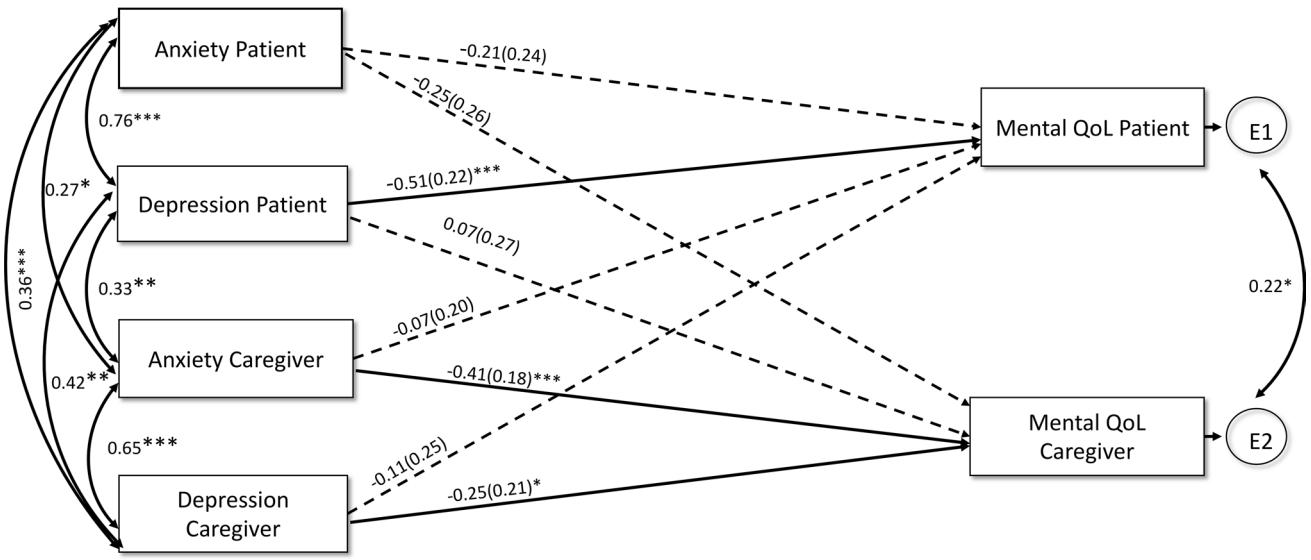

Fig. 1 Actor and partner effects of anxiety and depression on mental quality of life. In the graphical representation of the actor–partner interdependence model, the rectangles represent the independent and dependent variables; the two circles present the latent error terms; and the arrows describe the actor and partner effects. The curved double-headed arrows on the left represent the covariances between the independent variables, and the curved double-headed arrow on the right the correlation between the two error terms [43]. *QoL* quality of life; $*p<0.05$; $**p<0.01$; $***p<0.001$; standardized coefficients (β) are reported with standard error in parentheses.

saturated model with the model in which actor and partner effects, intercepts, error variances, means and variances were posed equal [43, 45]. Statistically significant χ^2 differences ($\Delta\chi^2$) were found for physical and mental QoL ($\Delta\chi^2$ (10) 95.326 $p < 0.001$ and 31.868 $p < 0.001$, respectively), indicating that the members of the dyads could be treated as distinguishable on the basis of their role.

Tests of similarity of the partner and actor effects

Different models were tested which constrained the actor effects and the partner effects for anxiety and depression to be equal in order to verify the similarity of the effects between the dyadic members. When there is a statistically significant $\Delta\chi^2$ test between the constrained model and the saturated model, the saturated model fits the data better than the constrained model, indicating the absence of posed similar effects [21].

Unstandardized (b) and standardized (β) regression coefficients, standard errors (SE) and confidence interval (CI) were considered to describe the models. The statistical significance level was set to ≤ 0.05 throughout all analyses. Due to the difficulty of predicting all the parameters a priori, a post hoc power analysis was performed based on the observed values. The socio and clinical characteristics were analyzed using the software IBM SPSS version 22.0 (IBM® SPSS® Statistics, USA), and the constrained models were computed using Mplus software version 6.12 (Muthén & Muthén, Los Angeles, CA, USA).

Ethical considerations

The study was conducted according to the principles of the Helsinki Declaration [46]. The primary study was approved by the Ethics Committees of the two institutions involved in the study. All participants received information about the study aims, the benefits and the data treatment and signed the written informed consent before completing the questionnaires. A numeric code was assigned to each participant to guarantee anonymity. Anonymity and confidentiality were also assured by storing the data in a reserved area.

Results

Over a period of 11 months, 300 patients with COPD diagnosis were admitted to the clinics and 235 met the inclusion criteria. Among them, only 143 patients were accompanied by their primary caregivers to the visit; 13 caregivers presented a diagnosis of tumor, therefore, were excluded. Forty dyads refused to participate due to lack of time, interest or a reluctance to sign the informed consent. Although they consented to participate in the study, ten dyads did not fill in the questionnaires on anxiety, depression and QoL. Therefore, the final sample consisted of 80 patient and caregiver dyads (56% of eligible dyads).

Characteristics of patients and caregivers

Sociodemographic characteristics of the participants are presented in Table 1. The patients were older than caregivers, mostly males, with low education level, retired from work and reported sufficient incomes. They suffered from COPD for 10.71 years and presented a mean of three chronic diseases, besides COPD. Fifty-eight percent of patients were diagnosed with severe and very severe COPD. Only 12.50% patients had ≥ 2 hospitalizations in the last year due to exacerbations (Table 2).

The caregivers were mainly females, spouses/partners, with high education level and retired. Most caregivers reported to taking care of patients for a mean of 10.62 years, and 37.50% of them cared for the patients for more than 20 h/week. In 40% of the cases, another family member helped in taking care of the person with COPD (Table 2).

Psychological status and quality of life in patients and caregivers

Patients presented higher depression symptoms and worse physical and mental QoL than caregivers. Comparable anxiety levels were instead found between patients and caregivers (Table 3). When stratified for severity of disease, statistically significant differences were observed, with more severe disease stages characterized by worse physical and mental QoL in both patients and caregivers, greater depression symptoms in patients and anxiety symptoms in caregivers. Regarding gender and type of family relations, the only significant differences were in female and spouse/partner caregivers presenting lower physical QoL (Online Resource 1).

PCS and MCS of patients and caregivers were significantly correlated with partner's anxiety and depression symptoms. Caregivers' PCS was correlated with patients' PCS and caregivers' MCS with patients' MCS. Patients' MCS was correlated with caregivers' PCS, whereas no correlation was found between caregivers' MCS and patients' PCS (Table 4).

Dyadic impact of psychological distress on quality of life

Since the anxiety and depression symptoms' scores were strongly correlated within persons, and both conditions define the status of psychological distress [47], they were included together in the analysis as predictors to control for

Table 1 Demographic characteristics of COPD patient and caregiver sample ($n=80$ dyads)

	Patient ($n=80$) M ± SD (range)	Caregiver ($n=80$) M ± SD (range)	p Value
Age (years)	76.40 ± 7.33 (60–92)	62.55 ± 13.78 (28–85)	0.334
Male	74.91 ± 7.84	68.90 ± 14.63	0.260
Female	78.31 ± 6.23	60.29 ± 12.85	0.341
Comorbidity	3.21 ± 2.04 (0–8)	2.03 ± 1.86 (0–7)	< 0.05
	n (%)	*n* (%)	
Gender			< 0.001
Male	45 (56.25)	21 (26.25)	
Female	35 (43.75)	59 (73.75)	
Education level in years			< 0.001
0–8 years	49 (61.25)	35 (43.75)	
9–13 years	29 (36.25)	37 (46.25)	
> 13 years	2 (2.50)	8 (10.00)	
Marital status			< 0.001
Married	54 (67.50)	60 (75.00)	
Single	8 (10.00)	20 (25.00)	
Widowed	18 (22.50)	–	
Employment status			0.406
Employed	5 (6.25)	31 (38.75)	
Unemployed	2 (2.50)	14 (17.50)	
Retired	73 (91.25)	35 (43.75)	
Income			< 0.001
Less than needed	11 (13.75)	18 (22.50)	
Enough for living	58 (72.50)	57 (71.25)	
More than needed	11 (13.75)	5 (6.25)	
Living with			< 0.001
Spouse/partner	47 (58.75)	50 (62.50)	
Family	22 (27.50)	28 (35.00)	
Alone	9 (11.25)	2 (2.50)	
Other	2 (2.50)	–	
Cohabitation with caregiver			
Yes	63 (78.75)	–	
No	17 (21.25)	–	

M mean, *SD* standard deviation

the reciprocal influence. Consequently, two APIM analyses were carried out to test the simultaneous effects of anxiety and depression on PCS and MCS in COPD patients and caregivers (Table 5).

Impact of psychological distress on mental quality of life

Three statistically significant actor effects were identified: patients' depressive symptoms negatively influencing their MCS ($\beta=-0.51$, $p<0.001$); caregivers' anxiety ($\beta=-0.41$, $p<0.001$) negatively impacting their MCS; and caregivers' depression ($\beta=-0.25$, $p<0.05$) negatively impacting their MCS. The $\Delta\chi^2$ tests between the saturated model and the models with the constraints of equality for the actor and partner effects of anxiety and depression on MCS were not statistically significant, indicating that the effects of depression and anxiety on mental QoL were similar in both members of the dyads (Online Resource 2). No statistically significant dyadic patterns, assessed through k parameter, were identified. The depression and anxiety effects on MCS are illustrated in Fig. 1.

Impact of psychological distress on physical quality of life

The model presented one statistically significant actor effect with patients' depressive symptoms negatively influencing their PCS ($\beta=-0.42$, $p<0.01$) and two partner effects with caregivers' anxiety worsening patients' PCS

Table 2 Clinical data of patients and caregiving characteristics

Patient	($n=80$) M ± SD (range)	Caregiver	($n=80$) M ± SD (range)
Years since diagnosis	0.71 ± 7.58 (1–40)	Years of caregiving	10.62 ± 8.80 (1–40)
	n (%)		*n* (%)
No. of hospitalizations		Caregiver	
0	47 (58.75%)	Spouse/partner	42 (52.50)
1	23 (28.75%)	Son/daughter	34 (42.50)
≥2	10 (12.50%)	Other family member	4 (5.00)
mMRC		Caregiving hours per week	
0	5 (6.25)	0–10	30 (37.50)
1	15 (18.75)	10–20	20 (25.00)
2	11 (13.75)	>20	30 (37.50)
3	20 (25.00)	Other caregivers	
4	29 (36.25)	Yes	32 (40.00)
GOLD ABCD		No	48 (60.00)
A	13 (16.25)		
B	34 (42.50)		
C	7 (8.75)		
D	26 (32.50)		

M mean, *SD* standard deviation, *mMRC* modified Medical Research Council dyspnea scale, *GOLD ABCD* ABCD assessment tool of Global Initiative for Obstructive Lung Disease

Table 3 Comparison of anxiety, depression and quality of life in patients and caregivers

	Patients ($n=80$) M ± SD (range)	Caregivers ($n=80$) M ± SD (range)	*t* test	*p* value
Depression (PHQ-9)	10.49 ± 6.04 (0–26)	7.28 ± 5.33 (0–27)	3.57	<0.001
Anxiety (GAD-7)	8.85 ± 5.61 (0–20)	7.69 ± 5.27 (0–21)	1.35	0.179
Physical QoL (SF-12 PCS)	35.72 ± 7.81 (19.35–54.64)	48.23 ± 8.46 (25.16–61.21)	−9.71	<0.001
Mental QoL (SF-12 MCS)	41.12 ± 11.15 (17.00–66.06)	44.81 ± 9.58 (20.25–62.48)	−2.25	0.026

M mean, *SD* standard deviation, *PHQ-9* Patient Health Questionnaire, *GAD-7* Generalized Anxiety Disorder, *QoL* quality of life, *SF-12 PCS* 12-Item Short-Form Health Survey Physical Component Summary, *SF-12 MCS* 12-Item Short-Form Health Survey Mental Component Summary

($\beta = -0.31$, $p < 0.05$) and caregivers' depression improving patients' PCS ($\beta = 0.35$, $p < 0.05$). The comparisons of the models where the partner effects and the actor effects of depression were constrained to be equal showed significant statistical differences with the saturated model ($\Delta\chi^2(1) = 4.862$, p 0.027, and $\Delta\chi^2(1) = 3.964$, p 0.047, respectively), indicating that the effect of depression on their own PCS was larger in patients than in caregivers and that the effect of caregiver' depression on patient's PCS was greater than the effect of the patient's depression on caregiver's PCS. Differently, the $\Delta\chi^2$ tests for the partner and actor effects of anxiety were not statistically significant expressing similar effects of anxiety on physical QoL in the dyad members (Online Resource 2). No dyadic pattern was identified. The APIM of depression and anxiety on PCS is depicted in Fig. 2.

Discussion

The study aim was to examine the effects of anxiety and depression on the physical and mental QoL of COPD patient–caregiver dyads, applying the APIM. We expected to find similar levels of anxiety and depression in our sample. Our results led to a partial support of our hypothesis. In fact, we found comparable levels of anxiety in COPD patients and caregivers, but higher levels of depression symptoms in patients. Contradicting results were also found in previous research. For example, Al-Gamal [18] and Kuhl et al. [17] found no differences between levels of anxiety and depression in patients with moderate and moderate/severe COPD and their caregivers. On the other hand, Mi et al. [15] and Badr et al. [19], studying patients

Table 4 Correlations of anxiety, depression and quality of life in patients and caregivers

		1	2	3	4	5	6	7
1	Patient depression (PHQ-9)							
2	Caregiver depression (PHQ-9)	0.424**						
3	Patient anxiety (GAD-7)	0.761**	0.360**					
4	Caregiver anxiety (GAD-7)	0.333**	0.649**	0.267*				
5	Patient physical QoL (SF-12 PCS)	− 0.290**	0.014	− 0.165	− 0.192			
6	Caregiver physical QoL (SF-12 PCS)	− 0.218	− 0.176	− 0.177	− 0.274*	0.307*		
7	Patient mental QoL (SF-12 MCS)	− 0.737**	− 0.444**	− 0.654**	− 0.365**	0.101	0.262*	
8	Caregiver mental QoL (SF-12 MCS)	− 0.366**	− 0.569**	− 0.400**	− 0.615**	0.215	0.170	0.480**

PHQ-9 Patient Health Questionnaire, *GAD*-7 Generalized Anxiety Disorder, *QoL* quality of life, *SF-12 PCS* 12-Item Short-Form Health Survey Physical Component Summary, *SF-12 MCS* 12-Item Short-Form Health Survey Mental Component Summary

*$p \leq 0.05$; **$p \leq 0.01$

Table 5 Actor–partner interdependence model parameter estimates for depression, anxiety, and mental and physical quality of life

	Mental quality of life (SF-12 MCS)				Physical quality of life (SF-12 PCS)			
	b	SE	*p* Value	*β*	*b*	SE	*p* Value	*β*
Actor effects								
Patient								
Anxiety	− 0.42	0.24	0.09	− 0.21	0.16	0.23	0.50	0.11
Depression	**− 0.94**	**0.22**	**< 0.001**	**− 0.51**	**− 0.55**	**0.22**	**< 0.01**	**− 0.42**
Caregiver								
Anxiety	**− 0.71**	**0.18**	**< 0.001**	**− 0.41**	− 0.41	0.24	0.09	− 0.26
Depression	**− 0.45**	**0.21**	**< 0.05**	**− 0.25**	0.10	0.28	0.74	0.06
Partner effects								
Caregiver to patient								
Anxiety	− 0.14	0.20	0.48	− 0.07	**− 0.45**	**0.22**	**< 0.05**	**− 0.31**
Depression	− 0.23	0.25	0.37	− 0.11	**0.52**	**0.26**	**< 0.05**	**0.35**
Patient to caregiver								
Anxiety	− 0.43	0.26	0.10	− 0.25	− 0.03	0.30	0.91	− 0.02
Depression	0.11	0.27	0.68	0.07	− 0.20	0.27	0.46	− 0.14

The statistically significant effects are indicated in bold

b unstandardized coefficients, *β* standardized coefficients within roles, *SE* standard error, *SF-12 PCS* 12-Item Short-Form Health Survey Physical Component Summary, *SF-12 MCS* 12-Item Short-Form Health Survey Mental Component Summary

with severe and mild COPD, respectively, found patients more depressed than their caregivers. Patients with less severe COPD stage, low caregiving hours and the presence of another caregiver could explain the lower level of depression in the caregivers of our sample.

Moreover, from the APIM analysis emerged that the psychological distress affects the QoL of COPD patients and caregivers consistently with prior research that used individual level of analysis [5, 9, 10, 14, 17, 48]. The most novel findings of our study derive from the analysis of the effect of anxiety and depression controlled for each other. We found that the mental QoL of caregivers is influenced by their anxiety and depression, and the mental QoL of patients is influenced mainly by their own depression. These results confirm the negative impact of anxiety and depression on the caregivers' mental QoL, as shown in

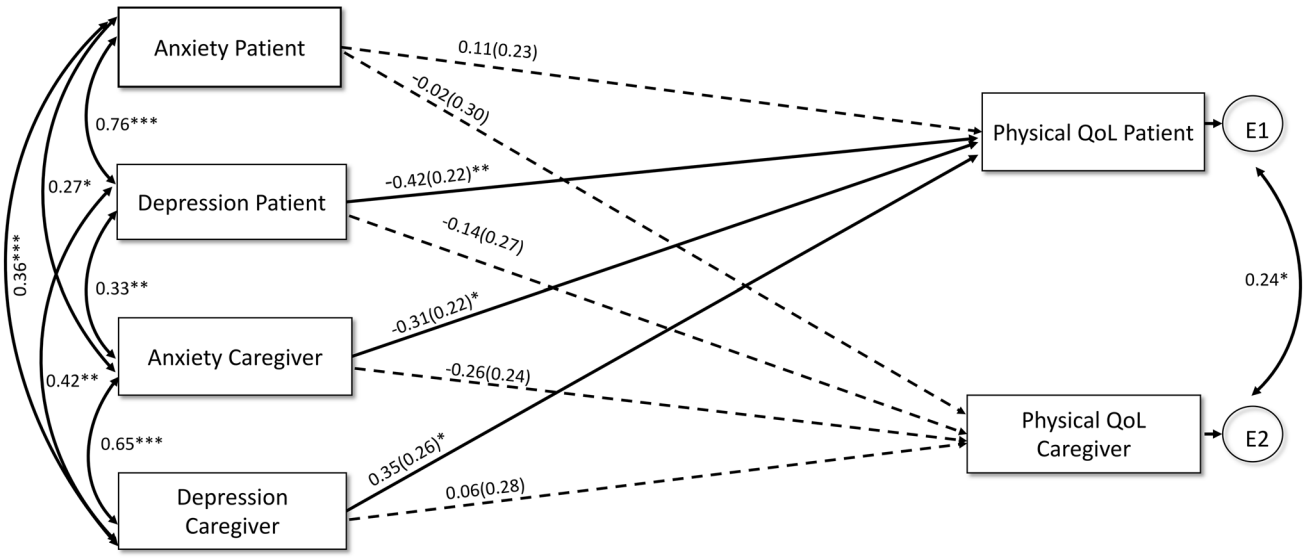

Fig. 2 Actor and partner effects of anxiety and depression on physical quality of life. *QoL* quality of life; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; standardized coefficients (β) are reported with standard error in parentheses

previous studies [15–18]. Moreover, our results reveal that the physical QoL of patients is influenced not only by their own depression, but also by the caregiver's anxiety and depression symptoms. In fact, we found that caregivers' anxiety negatively influences the patients' physical QoL and, unexpectedly, that caregivers' depressive symptoms are associated with better patients' physical QoL. This contradictory result can have two possible explanations: when COPD patients have caregivers with depression symptoms, they cannot count on the caregivers' support and must assume more responsibility for maintaining their own health; or, in the presence of depressed caregivers, other family members take on the responsibility of the patient's care, which improves the patient's physical QoL. The presence of other informal caregivers besides the primary caregiver was reported by 40% of the caregivers in our study and could support the second hypothesis. In the dyadic literature, we could not find any similar result and further studies are needed to confirm such an effect.

Although dyadic studies which analyze the influence of emotional distress in patients with chronic diseases and their caregivers are few, they all support the interdependence between the caregiver and care receiver found in COPD dyads. For example, for patients with stroke, the caregivers' psychological status negatively affects the patient's physical QoL, but not the mental QoL [25]. Also, for heart failure, the caregiver's depression and anxiety negatively influence the patient's QoL [24]. In lung and colorectal cancer, caregivers reported poorer mental health than patients, denoting the psychological impact of the patients' disease on caregivers [49]. Further, in prostate cancer, partners' psychological distress negatively influenced the mental QoL of patients [50].

Strengths and limitations

This study has several strengths. It is the first study to use the APIM to describe the effects of anxiety and depression on QoL. Moreover, this study, which measures the simultaneous influence of anxiety and depression on the physical and mental dimensions of QoL, permits the identification of different effects on these two dimensions.

Nevertheless, this study presents a few limitations. Firstly, post hoc power analyses performed using a specific calculator developed for APIM [51], in which the observed standardized regression coefficients were entered, detected a power ≥ 0.80 only for patient's actor effect of depression on MCS and PCS, caregiver's actor effect of anxiety on MCS and caregiver's partner effect of depression on patient PCS; for such effects, the coefficients were of large or medium size (see Online Resource 3). Secondly, in our sample, no dyadic pattern was identified and, therefore, the type of dependency in COPD dyads was not described. Therefore, in order to discover additional small effects and specific dyadic patterns further studies with larger samples are needed. Secondly, the cross-sectional design did not allow for causal-effect interpretations. Since emotional distress and QoL are strongly correlated and the relation between them could be recursive, longitudinal studies should be conducted to determine the direction of the relations. In addition, participants had homogeneous social characteristics and came from the same geographical area, although they were enrolled in two different settings; therefore, the generalizability of our findings could be limited. Furthermore, we enrolled dyads who voluntarily agreed to participate; thus, our findings might be confined to

more psychologically healthy participants. Lastly, the COPD patients and caregivers could have influenced each other during the questionnaire compilation, leading to similar results, even if separate compilation was recommended.

Implications for practice and research

Several clinical and research implications emerge from our study. Dynamic interpersonal relationships and mutual influence on partners' outcomes are present in COPD dyads. As the caregivers' psychological distress influences the physical QoL of COPD patients, health-care professionals should assess anxiety and depression symptoms not only in patients, but also in caregivers, and psychosocial interventions should be provided to both members of the COPD dyad because caregivers' emotional distress can reduce the effectiveness of interventions directed only at patients. Moreover, health-care personnel should also consider the caregivers as potential care recipients because their mental and physical health could be compromised by the burden of caregiving.

Moreover, the study findings highlight the utility of dyadic analysis in determining how individuals' anxiety and depression influence the QoL of both dyad members. However, investigations on psychological distress in COPD dyads are still limited. Further research on larger and multisite samples and on patients and caregivers with more severe symptoms of anxiety and depression is necessary to confirm our findings and determine the influence of the emotional distress of caregiver on patient's mental and physical's QoL. Additionally, future studies should consider the longitudinal observation of the psychological impact on the QoL in COPD dyads to confirm the casual effects. Moreover, the effectiveness of the interventions directed to the dyads to improve the psychological distress on COPD patients and caregivers should be assessed.

Conclusions

This study, through the application of APIM, provided evidence of the interdependence of patients' and caregivers' psychological distress on the physical and mental QoL in COPD dyads. In particular, this study demonstrated the influence of the caregivers' psychological distress on COPD patient's physical QoL. Therefore, health-care professionals should consider these findings when planning psychosocial interventions in COPD patients.

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Author contributions The authors confirm that study design, data collection, analysis and interpretation, manuscript preparation and final approval of the version to be published have been carried out by all authors.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval The study was approved by the Campus Bio Medico University of Rome (Prot: 32/16 OSS) and the Institute of Hospitalization and Scientific Care IRCCS-I.F.O. (Prot: 8393/17) Ethics Committees and was conducted in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all participants included in the study.

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