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Medication Compliance in COPD Patients

Jacek Polański, Mariusz Chabowski, Natalia Świątoniowska-Lonc, Grzegorz Mazur, and Beata Jankowska-Polańska

Abstract

Chronic obstructive pulmonary disease (COPD) is one of the most severe public health problems and a leading cause of death worldwide. One of the main reasons for poor control of the disease is low patient compliance with treatment plan. The aim of the study was to investigate sociodemographic and health status factors that may have an influence on adherence to treatment. There were 106 inpatients (F/M, 42/64; mean age 70 ± 6 years) with COPD enrolled into this retrospective study. Patients completed the Adherence to Refills and Medications Scale (ARMS) to assess adherence to therapy. We found that the mean ARMS score was 23.1 ± 6.8. About 86% of patients had low adherence, and 14% had good adherence (mean score 3.2 ± 2.4). The low-adherence patients were more likely to be older ($p = 0.020$), female ($p = 0.011$), single ($p = 0.019$), not professionally active ($p = 0.049$), hospitalized more often ($p = 0.005$) and for a longer time ($p = 0.046$), feel worse ($p = 0.023$), experience a greater impact of the disease on sleep quality ($p = 0.008$) and daily activities ($p = 0.001$), and had a higher GOLD stage of COPD when compared to patients with good adherence patients ($p = 0.012$). Multiple factor analysis demonstrates that independent adverse predictors of the ARMS score included the following: being single (OR = 3.18), having had more than eight hospitalizations (OR = 1.18), and experiencing dysfunction in daily activities (OR = 1.79). Male gender (OR = 0.77) and longer than 21-day hospitalizations (OR = 0.93) were independent positive predictors of adherence. In conclusion, COPD patients demonstrate a low level of adherence to pharmacotherapy. Adherence is adversely affected by sociodemographic (older age, female gender, being single, and professionally inactive) and clinical factors (more frequent hospitalizations, perception of poor well-being, disordered sleep and daily functioning, and a higher GOLD stage).

Keywords

Adherence to treatment · COPD · Health status · Pharmacotherapy · Sociodemographic factors

J. Polański and G. Mazur
Department and Clinic of Internal and Occupational Diseases and Hypertension, Wroclaw Medical University, Wroclaw, Poland

M. Chabowski
Department of Oncology and Palliative Care, Wroclaw Medical University, Wroclaw, Poland

N. Świątoniowska-Lonc and B. Jankowska-Polańska (✉)
Department of Clinical Nursing, Faculty of Health Science, Wroclaw Medical University, Wroclaw, Poland
e-mail: bianko@poczta.onet.pl

1 Introduction

Chronic obstructive pulmonary disease (COPD) is a leading cause of chronic morbidity and mortality worldwide. It involves a permanent restriction of air flow through the airways, which is typically progressive and associated with a significant chronic inflammatory response of the respiratory tract to inhaled particles and gases. The Global Burden of Disease (GBD) organization estimates that the number of COPD patients in the world exceeds 328 million, including 168 million men and 160 million women (Vos et al. 2012). In 1990, COPD was the sixth most common cause of death, but the mortality is growing. In the year 2000, COPD already ranked fourth, and by 2020, an estimated 4.7 million people will die from COPD, making it the third most common cause of death worldwide (López-Campos et al. 2016). These changes are due to a rise in tobacco smoking, increasing environmental pollution in developing countries, and a longer life expectancy. Epidemiological studies covering the entire Polish population are lacking, but available estimates put the number of COPD patients in Poland at two million (Niżankowska–Mogilnicka et al. 2007).

In most patients, the available pharmaceutical treatment enables full control of the disease, significant alleviation of symptoms, and a reduction of exacerbation risk. One of the main reasons for poor control of the disease is low adherence to treatment plan, including pharmacotherapy, lifestyle and diet modifications, and a lack of cooperation with the medical caretakers. In 2003, WHO listed nonadherence to treatment among the world's most serious health problems, as it constitutes a major obstacle to benefiting from evidence-based therapy (Burkhart and Sabaté 2003). According to a WHO report, less than 50% of chronically ill patients adhere to their treatment, which adversely affects treatment effectiveness, patients' quality of life, and the economic side of treatment. In Poland, the percentage of COPD patients who continue treatment with inhaled medication at the end of 1-year follow-up does not exceed 21% (Kardas et al. 2012).

In literature, there is no clarity yet regarding the impact of certain factors on adherence in COPD. Therefore, the purpose of the present study was to determine the influence of the selected variables on adherence to pharmaceutical treatment in COPD patients.

2 Methods

2.1 Patients and Survey Instrument

This retrospective study included 106 inpatients (F/M, 42/64; mean age 70 ± 6 years) diagnosed with COPD and treated at the Lower Silesian Lung Center in Wroclaw, Poland. The Adherence to Refills and Medications Scale (ARMS) was a survey tool to assess adherence to therapy. Sociodemographic and clinical data were obtained from medical files. The ARMS has been developed by Kripalani et al. (2009) and used in patients with coronary artery disease and other chronic conditions, including hypertension, dyslipidemia, and diabetes mellitus. The survey consists of 12 items gathered in 2 subscales: adherence to taking medications (8 items) and adherence to refilling prescriptions (4 items). Responses are scored on a 4-point Likert-type scale as "none", "some of the time", "most of the time", and "all of the time", assuming the values from 1 to 4, respectively. The score range is from 12 to 48; the lower the score, the better the adherence (Lomper et al. 2018).

Sociodemographic data were obtained from the patient files and concerned gender, age, marital status, residence, education, and professional activity. Clinical data referred to body mass index (BMI), cigarette smoking habit, number and duration of hospitalizations, perceived well-being, impact of the disease on sleep quality and daily activities, and medications. Patients were stratified according to the current GOLD classification of COPD severity, using a four-stage GOLD classification: GOLD I mild, GOLD II moderate, GOLD III severe, and GOLD IV very severe (Le et al. 2019).

2.2 Statistical Elaboration

Continuous variables were expressed as means ±SD and ordinal variables as counts and percentages. Quantitative variables were assessed for significance of differences using the Mann-Whitney U test. Comparison of qualitative variables was performed using the Chi-squared test with Yates's correction for 2 × 2 tables or with Fisher's exact test in case of low counts. The influence of quantitative variables on the dichotomous variable (high vs. low adherence) was analyzed using logistic regression, and the results were presented as odds ratio (OR) with a 95% confidence interval (CI). Multivariate analysis of the independent influence of the variables studied on the quantitative variable was performed using linear regression, and the results were shown as regression model variable values with a 95% confidence interval (95% CI). A p-value <0.05 defined statistical significance of differences and associations. The analysis was performed using the R software v3.6.1 (R Core Team 2019).

3 Results

3.1 Sociodemographic and Clinical Characteristics of Patients in Relation to Adherence to Treatment

A total ARMS score of 12–15 points was interpreted as high adherence and scores of ≥16 as low adherence. Accordingly, low adherence was found in 85.9% of patients and high adherence in the remaining 14.1%; a difference between the groups was significant ($p < 0.05$). In the low-adherence group, the patients predominated who were female, older, widowed, single, and retired (Table 1).

Low-adherence patients were hospitalized more often, and their current hospitalization was longer. Overall, patients in the low-adherence group had more severe disease and poorer perception of well-being and experienced a more significant impact of COPD on daily activities and sleep (Table 2).

Table 1 Sociodemographic characteristics of chronic obstructive pulmonary disease (COPD) patients in relation to the level of adherence to therapy

Variable		High adherence ($n = 15$)	Low adherence ($n = 91$)	All ($n = 106$)	*p*-value
Age (year)	Mean ± SD	66.8 ± 4.81	70.7 ± 6.0	70.2 ± 5.9	0.020
BMI (kg/m^2)	Mean ± SD	25.0 ± 3.3	25.3 ± 6.0	25.2 ± 5.7	0.892
Pack-years	Mean ± SD	28.7 ± 18.1	37.6 ± 24.9	36.3 ± 24.2	0.132
Gender	Female	1 (6.7%)	41 (45.1%)	42 (39.6%)	0.011
	Male	14 (93.3%)	50 (55.0%)	64 (60.4%)	
Marital status	In relationship	13 (86.7%)	44 (48.4%)	57 (53.8%)	0.019
	Single	0 (0.0%)	20 (22.0%)	20 (18.9%)	
	Widowed	2 (13.3%)	27 (29.7%)	29 (27.4%)	
Residence	Urban	5 (33.3%)	27 (29.7%)	32 (30.2%)	0.768
	Rural	10 (66.7%)	64 (70.3%)	74 (69.8%)	
Education	Primary	3 (20.0%)	35 (38.5%)	38 (35.9%)	0.295
	High school	8 (53.3%)	42 (46.2%)	50 (47.2%)	
	College/ university	4 (26.7%)	14 (15.4%)	18 (17.0%)	
Professional activity	Active	8 (53.3%)	21 (23.1%)	29 (27.4%)	0.049
	Unemployed	0 (0.0%)	4 (4.0%)	4 (3.8%)	
	Retired	7 (46.7%)	66 (72.3%)	73 (68.9%)	
Cigarette smoking	Smokers	12 (80.0%)	72 (79.1%)	84 (79.3%)	1.000
	Non-smokers	3 (20.0%)	19 (20.9%)	22 (20.8%)	

BMI body mass index. The p-value corresponds to high vs. low-adherence difference for all items in a given category of variables

Table 2 Clinical characteristics of chronic obstructive pulmonary disease (COPD) patients in relation to the level of adherence to therapy

Variable		High adherence ($n = 15$)	Low adherence ($n = 91$)	All ($n = 106$)	p-value
Number of hospitalizations	1–4	13 (86.7%)	38 (41.8%)	51 (48.1%)	0.005
	5–8	2 (13.3%)	38 (41.8%)	40 (37.7%)	
	>8	0 (0.0%)	15 (16.5%)	15 (14.2%)	
Current hospitalization	< 7 days	12 (80.0%)	37 (40.7%)	49 (46.2%)	0.046
	8–14 days	3 (20.0%)	33 (36.3%)	36 (34.0%)	
	15–21 days	0 (0.0%)	15 (16.5%)	15 (14.2%)	
	> 21 days	0 (0.0%)	6 (6.6%)	6 (5.7%)	
Perceived well-being	Very good	0 (0.0%)	1 (1.1%)	1 (0.9%)	0.023
	Good	11 (73.3%)	35 (38.5%)	46 (43.4%)	
	Moderate	4 (26.7%)	30 (33.0%)	34 (32.1%)	
	Poor	0 (0.0%)	25 (27.5%)	25 (23.6%)	
Impact of COPD on daily activities	None	2 (13.3%)	5 (5.5%)	7 (6.6%)	0.001
	Slight	10 (66.7%)	17 (18.7%)	27 (25.5%)	
	Moderate	2 (13.3%)	28 (30.8%)	30 (28.3%)	
	Significant	1 (6.7%)	18 (19.8%)	19 (17.9%)	
	Very significant	0 (0.0%)	23 (25.3%)	23 (21.7%)	
Impact of COPD on sleep	None	9 (60.0%)	15 (16.5%)	24 (22.6%)	0.008
	Slight	3 (20.0%)	18 (19.8%)	21 (19.8%)	
	Moderate	1 (6.7%)	15 (16.5%)	16 (15.1%)	
	Significant	1 (6.7%)	18 (19. 8%)	19 (17.9%)	
	Very significant	1 (6.7%)	25 (27.5%)	26 (24.5%)	
Feeling rested after a night's sleep	Yes	10 (66.7%)	30 (33.0%)	40 (37.7%)	0.027
	No	5 (33.3%)	61 (67.0%)	66 (62.3%)	
Medications[a]	SAMA	5 (33.3%)	23 (25.3%)	28 (26.4%)	0.535
	SABA	2 (13.3%)	11 (12.1%)	13 (12.3%)	1.000
	LABA	8 (53.3%)	55 (60.4%)	63 (59.4%)	0.814
	LAMA	5 (33.3%)	57 (62.6%)	62 (58.5%)	0.064
	Theophylline	1 (6.7%)	14 (15.4%)	15 (14.2%)	0.690
	Glucocorticoids	1 (6.7%)	30 (33.0%)	31 (29.3%)	0.062
GOLD stage	I	9 (60.0%)	18 (19.8%)	27 (25.5%)	0.012
	II	5 (33.3%)	39 (42.9%)	44 (41.5%)	
	III	1 (6.7%)	22 (24.2%)	23 (21.7%)	
	IV	0 (0.0%)	12 (13.2%)	12 (11.3%)	

[a]Total exceeds 100%, as the item allowed for multiple choices. The p-value corresponds to high- vs. low-adherence difference for all items in a given category of variables, unless otherwise indicated

3.2 Level of Adherence to Treatment

The mean ARMS score was 23.1 ± 6.8 points or 1.9 points *per* question, meaning that the average frequency of adherent behaviors was slightly lower than "some of the time". The mean score concerning "medication taking" subscale was 15.0 ± 4.4 points or 1.9 points *per* question, meaning that the nonadherence to taking medications also was slightly lower than "some of the time". Likewise, the mean score in "prescription refilling" subscale was 8.1 ± 2.7 points or 2.0 points *per* question, meaning that the adherence to getting prescription refills also corresponded to "some of the time" category (Table 3).

Table 3 Adherence to therapy in chronic obstructive pulmonary disease (COPD) patients of the study

ARMS	Range (points)	*n*	Mean ± SD	Mean *per* question
Overall ARMS score	12–48	106	23.1 ± 6.8	1.9
Taking medications	8–32	106	15.0 ± 4.4	1.9
Refills	4–16	106	8.1 ± 2.7	2.0

ARMS the adherence to refills and medications scale

3.3 Multiple Factor Analysis of the Impact of Variables on Adherence to Treatment

Logistic regression demonstrates a single significant independent predictor of low adherence to treatment, which turned out to be male gender, with OR = 0.77, meaning a 23.6% decrease in adherence compared to females ($p < 0.05$). Linear regression demonstrates that the independent significant predictors of a total ARMS score were the following (Table 4):

- Marital status: compared to being married, being widowed increased the score by a mean of 3.2 points.
- Number of hospitalizations: compared to one to four hospitalizations, more than eight hospitalizations increased the score by a mean of 7.5 points.
- Duration of current hospitalization: compared to hospitalization shorter than 7 days, hospitalization longer than 21 days decreased the score by a mean of 8.2 points.
- Impact of COPD on daily activities: compared to no impact, a strong impact increased the score by a mean of 15.6.

3.4 Multiple Factor Analysis for Taking Medications and Refilling Prescriptions

Linear regression demonstrates that the independent significant ($p < 0.05$) predictors of ARMS score in the subscale of taking medications were the following (Table 5):

- Number of hospitalizations: compared to one to four hospitalizations, more than eight hospitalizations increased the score by a mean of 4.8 points.
- Duration of current hospitalization: compared to hospitalization shorter than 7 days, hospitalization longer than 21 days decreased the score by a mean of 5.2 points.
- Impact of COPD on daily activities: compared to no impact, a significant impact increased the score by a mean of 10.1 points.

Significant predictors of ARMS score in the subscale of refilling prescriptions were the following:

- Number of hospitalizations: compared to one to four hospitalizations, more than eight hospitalizations increased the score by a mean of 2.7 points.
- Impact of COPD on daily activities: compared to no impact, a significant impact increased the score by a mean of 5.5 points.

4 Discussion

The literature data indicate that COPD patients have a lower level of adherence than those with cardiovascular disease, hypercholesterolemia, osteoporosis, depression, or diabetes. COPD treatment is primarily based on inhalation therapy, though most patients prefer oral medications. Adherence in patients with inhalation therapy is low. In a study by Wiśniewski et al. (2014), 67% of patients adhered to treatment just for up to 30 days after discharge from the hospital. In

Table 4 Multiple factor analysis of the impact of variables on the level of adherence to therapy in chronic obstructive pulmonary disease (COPD) patients

Variable		Adherence			Total score		
		OR	95% CI	*p*	OR	95% CI	*p*
Age (year)		1.01	0.99; 1.02	0.528	0.11	−0.20; 0.41	0.490
BMI (kg/m^2)		0.10	0.98; 1.01	0.744	−0.15	−0.39; 0.09	0.222
Pack-years		1.00	0.99; 1.01	0.761	−0.05	−0.17; 0.06	0.355
Gender	Female	1	ref.		ref.		
	Male	0.77	0.67; 0.91	0.001	−0.67	−3.21; 1.87	0.601
Marital status	In relationship	1.00	ref.		ref.		
	Single	1.11	0.90; 1.37	0.324	1.13	−2.40; 4.66	0.525
	Widowed	1.02	0.85; 1.24	0.825	3.18	0.06; 6.30	
Residence	Urban	1.00	ref.		ref.		
	Rural	1.12	0.93; 1.36	0.231	−0.16	−3.38; 3.06	0.923
Education	Primary	1.00	ref.		ref.		
	High school	0.90	0.76; 1.08	0.260	−0.99	−4.01; 2.03	0.517
	College/ university	0.89	0.71; 1.13	0.338	−0.73	−4.74; 3.29	0.718
Professional activity	Active	1.00	ref.		ref.		
	Unemployed	1.09	0.75; 1.63	0.658	3.68	−3.12; 10.47	0.284
	Retired	1.06	0.87; 1.31	0.553	−2.89	−6.38; 0.61	0.104
Number of hospitalizations	1–4	1.00	ref.		ref.		
	5–8	1.15	0.88; 1.50	0.323	4.27	−0.31; 8.86	0.067
	> 8	1.18	0.81; 1.72	0.406	7.51	1.03; 13.98	0.024
Current hospitalization	< 7 days	1.00	ref.		ref.		
	8–14 days	0.99	0.79; 1.23	0.914	−2.33	−6.07; 1.41	0.218
	15–21 days	0.95	0.67; 1.36	0.787	−4.49	−10.58; 1.60	0.146
	> 21 days	0.93	0.59; 1.47	0.748	−8.22	−16.04; −0.40	0.040
Impact of COPD on daily activities	None	1.00	ref.		ref.		
	Slight	1.03	0.75; 1.41	0.868	−0.54	−5.91; 4.82	0.841
	Moderate	1.36	0.89; 2.09	0.161	2.64	−4.66; 9.95	0.472
	Significant	1.64	0.99; 2.71	0.060	4.82	−3.81; 13.44	0.269
	Very significant	1.787	0.89; 3.60	0.109	15.60	3.60; 27.59	0.012

(continued)

Table 4 (continued)

Variable		Adherence			Total score		
		OR	95% CI	*p*	OR	95% CI	*p*
SAMA	No	1.00	ref.		ref.		
	Yes	1.01	0.80; 1.30	0.966	−0.32	−4.19; 3.56	0.871
SABA	No	1.00	ref.		ref.		
	Yes	1.28	0.94; 1.74	0.126	2.71	−2.60; 8.03	0.312
LABA	No	1.00	ref.		ref.		
	Yes	1.01	0.82; 1.25	0.893	−0.44	−4.00; 3.12	0.806
LAMA	No	1.00	ref.		ref.		
	Yes	1.07	0.86; 1.34	0.543	0.08	−3.73; 3.88	0.969
Theophylline	No	1.00	ref.		ref.		
	Yes	0.93	0.68; 1.28	0.674	−1.38	−6.81; 4.06	0.615
Glucocorticoids	No	1.00	ref.		ref.		
	Yes	1.20	0.86; 1.68	0.289	−0.94	−6.68; 4.79	0.744
GOLD stage	I	1.00	ref.		ref.		
	II	1.11	0.82; 1.50	0.519	2.54	−2.67; 7.75	0.334
	III	0.92	0.54; 1.57	0.749	7.27	−1.94; 16.47	0.120
	IV	1.01	0.49; 2.06	0.981	9.85	−2.40; 22.09	0.113

Data are odds ratio (OR) 95% confidence intervals (95% CI); *BMI* body mass index; *SAMA* short-acting muscarinic antagonist; *SABA* short-acting inhaled beta-agonist; *LABA* long-acting β2-agonists; *LAMA* long-acting muscarinic antagonists.

screening tests performed in daily clinical practice, adherence to treatment in asthma and COPD patients rarely exceeds 50%. In the present study, good adherence was found in just 14.2% of patients. This is a considerably lower percentage than that found in other studies.

There is an ongoing discussion on the influence sociodemographic variables have on adherence. COPD patients who live alone often nonadhere to treatment. In studies by Bourbeau and Bartlett (2008) and Khdour et al. (2012), sociodemographic factors failed to associate with adherence to treatment. On the other hand, Tashkin (1995) has demonstrated that a stable family situation and available social support are linked to better adherence. Social support is among the most commonly reported predictors in chronically ill patients. Research has repeatedly shown a beneficial impact of social support on quality of life in patients with high blood pressure, acute coronary syndromes, atrial fibrillation, and heart failure (Ji et al. 2019). Social support plays an essential role in reducing stress, anxiety, and depression and in limiting the adverse influence of frailty in elderly patients.

In the present study, one factor that significantly affected adherence to treatment was the patient's daily functioning. COPD patients often quit work due to dyspnea and other symptoms, which decreases the perception of well-being and raises economic difficulties. All has an impact on both motivation to adhere to treatment and prescription refilling. The COPD patients in this study were in the seventh decade and often times with comorbidities, which made them use polypharmacy. The use of multiple drugs

Table 5 Multiple factor analysis of the impact of variables on taking medications and refilling prescriptions in chronic obstructive pulmonary disease (COPD) patients

Variable		Taking medications			Refilling prescriptions		
		r	95% CI	*p*	*r*	95% CI	*p*
Age (year)		0.05	−0.15; 0.25	0.612	0.06	−0.07; 0.18	0.382
BMI (kg/m^2)		−0.09	−0.25; 0.07	0.265	−0.06	−0.16; 0.04	0.230
Pack-years		−0.03	−0.11; 0.05	0.422	−0.02	−0.07; 0.02	0.331
Gender	Female	ref.			ref.		
	Male	−1.12	−2.78; 0.55	0.185	0.45	−0.60; 1.49	0.398
Marital status	In relationship	ref.			ref.		
	Single	0.46	−1.84; 2.77	0.690	0.67	−0.79; 2.12	0.362
	Widowed	2.04	−0.00; 4.07	0.050	1.15	−0.14; 2.43	0.079
Residence	Urban	ref.			ref.		
	Rural	−0.31	−2.41; 1.80	0.770	0.15	−1.17; 1.48	0.819
Education	Primary	ref.			ref.		
	High school	−0.50	−2.47; 1.47	0.614	−0.49	−1.73; 0.76	0.438
	College/ university	−0.22	−2.84; 2.41	0.869	−0.51	−2.16; 1.14	0.538
Professional activity	Active	ref.			ref.		
	Unemployed	2.52	−1.92; 6.96	0.261	1.15	−1.64; 3.95	0.414
	Retired	−2.11	−4.39; 0.17	0.070	−0.78	−2.21; 0.66	0.286
Number of hospitalizations	1–4	ref.			ref.		
	5–8	2.78	−0.22; 5.77	0.069	1.50	−0.39; 3.38	0.118
	> 8	4.79	0.55; 9.02	0.027	2.72	0.06; 5.39	0.045
Current hospitalization	< 7 days	ref.			ref.		
	8–14 days	−0.82	−3.27; 1.62	0.504	−1.51	−3.05; 0.03	0.055
	15–21 days	−2.02	−6.00; 1.96	0.314	−2.46	−4.97; 0.04	0.054
	> 21 days	−5.24	−10.35; −0.13	0.045	−2.98	−6.19; 0.24	0.069
Impact of COPD on daily activities	None	ref.					
	Slight	0.11	−3.40; 3.62	0.951	−2.86	1.56; 0.56	0.559
	Moderate	2.03	−2.74; 6.81	0.398	−2.39	3.62; 0.69	0.686
	Significant	3.41	−2.23; 9.05	0.231	−2.14	4.95; 0.43	0.432
	Very significant	10.11	2.27; 17.95	0.012	0.55	10.42; 0.03	0.030

(continued)

Table 5 (continued)

Variable		Taking medications			Refilling prescriptions		
		r	95% CI	*p*	*r*	95% CI	*p*
SAMA	No	ref.					
	Yes	0.095	−2.44; 2.63	0.941	−2.01	1.18; 0.61	0.608
SABA	No	ref.					
	Yes	2.053	−1.42; 5.53	0.242	−1.53	2.84; 0.55	0.550
LABA	No	ref.					
	Yes	−0.042	−2.37; 2.29	0.972	−1.86	1.07; 0.59	0.589
LAMA	No	ref.					
	Yes	0.985	−1.50; 3.47	0.432	−2.48	0.66; 0.25	0.250
Theophylline	No	ref.					
	Yes	−0.86	−4.42; 2.69	0.63	−2.75	1.72; 0.65	0.647
Glucocorticoids	No	ref.					
	Yes	−1.49	−5.24; 2.26	0.429	−1.81	2.91; 0.64	0.642
GOLD stage	I	ref.					
	II	1.34	−2.07; 4.74	0.436	−0.94	3.35; 0.27	0.267
	III	4.81	−1.21; 10.82	0.115	−1.33	6.24; 0.20	0.199
	IV	5.45	−2.55; 13.45	0.178	−0.64	9.43; 0.09	0.086

Data are regression coefficient *r* 95% confidence intervals (95% CI); *BMI* body mass index, *SAMA* short-acting muscarinic antagonist, *SABA* short-acting inhaled beta-agonist, *LABA* long-acting β2-agonists, *LAMA* long-acting muscarinic antagonists

increases the risk of adverse effects, leading to a belief that the main treatment is rather ineffective or even harmful. As a result, patients often randomly discontinue medications, which worsens the course of a disease.

An association between perception of one's health and adherence has been documented (Wiśniewski et al. 2014). According to Sanduzzi et al. (2014), adverse consequences of nonadherence include a gradual deterioration of quality of life, a sense of lack of control over a disease, and a higher mortality. Likewise, poor treatment outcome associates with poor adherence (Mäkelä et al. 2013; van der Molen et al. 2002). In the present study, both frequent and longer hospitalizations were significant predictors of lower adherence. This finding is in line with those of the 3-year-long TORCH study that has demonstrated a greater than twofold increase in the risk of death and a nearly twofold increase in the risk of rehospitalization in nonadherent patients (Vestibo et al. 2009). On the other hand, frequent COPD exacerbations may increase the perception of treatment necessity and thus portend better adherence.

In the present study, we found that female gender was associated with significantly lower adherence to treatment. That finding is at variance with most other studies, although some studies do report an association between gender and adherence (Kokturk et al. 2018; Müllerová et al. 2016). The influence of gender on adherence may be related to the increasing percentage of women who smoke cigarettes, a habit that may adversely affect daily functioning. Another factor, often reported as a predictor of adherence to treatment,

is age. In this study we found that older age significantly associates with lower adherence. The finding is in line with the reports that show older age is a risk factor for nonadherence due to forgetfulness, cognitive impairment, and polypharmacy (Shrestha et al. 2015). However, the issue remains contentious as some studies show that old patients are more likely to adhere to treatment (Rand et al. 1995; Turner et al. 1995). Yet other studies fail to support any association between age and adherence (Khdour et al. 2012).

We also report in here that nonadherent patients belonged to higher GOLD classes and thus suffered from more severe COPD. Adherence has to do with the severity of respiratory function deterioration. Dyspnea, the most bothersome symptom, is related to a decrease in FEV1% (Duarte–de–Araújo et al. 2018). Nonetheless, a link between COPD severity and adherence is not full clear. Some studies show that more severe course of COPD increases the patients' motivation to counteract distressing symptoms (Ivanov et al. 2018; Jouleh et al. 2018). In contradistinction, Liao and Chen (2019) have reported that as many as 81% of patients with a low severity of COPD, assessed from a proportion of days covered with at least one COPD maintenance medication of more than 80%, adhere to treatment. In the same vein, Leiva–Fernández et al. (2014) have reported that patients with mild-to-moderate COPD use up more prescriptions for inhaled corticosteroids.

In conclusions, we believe we have shown in this study that COPD patients, in the main, demonstrate a low level of adherence to therapy. Older age, female gender, being single and professionally inactive, frequent and longer hospitalizations, poor perception of well-being, and more sever course of COPD are all factors that significantly impact adherence to treatment. Medical practice should include an evaluation of adherence to therapy in COPD patients to achieve the optimum outcome.

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Conflicts of Interest The authors declare no conflicts of interest in relation to this article.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The study was approved by the Ethics Committee of Wroclaw Medical University (approval no. 371/2019).

Informed Consent Written informed consent was obtained from all individual participants included in the study.

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