ORIGINAL ARTICLE

Chronic obstructive pulmonary disease affects the angiographic presentation and outcomes of patients with coronary artery disease treated with percutaneous coronary interventions

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KEY WORDS

chronic obstructive pulmonary disease, clinical and angiographic presentation, nationwide database, percutaneous coronary intervention

ABSTRACT

INTRODUCTION The incidence of chronic obstructive pulmonary disease (COPD) in patients treated with percutaneous coronary intervention (PCI) is underestimated, and the effect of COPD on atherosclerosis and the outcomes of PCI is not fully understood.

OBJECTIVES The aim of this study was to assess the impact of COPD on periprocedural outcomes of PCI, as well as its relationship with clinical presentation and the type of coronary artery lesions.

PATIENTS AND METHODS Data were prospectively collected using a national electronic registry of PCI procedures performed in Poland between January 2015 and December 2016. Out of the 221 187 PCIs, 5594 patients had been diagnosed with COPD before the intervention.

RESULTS Patients with COPD were older than those without COPD (mean [SD] age, 70.3 [9.9] years vs 67 [10.8] years; $P < 0.001$) and more often were males (72.3% vs 67.8%; $P < 0.001$). Non–ST-segment elevation myocardial infarction (NSTEMI) was a more common clinical presentation of coronary artery disease (CAD) in the COPD group, while ST-segment elevation myocardial infarction (STEMI) occurred more frequently in the non-COPD group. Multivessel disease (MVD) with or without left main coronary artery (LMCA) involvement and separate LMCA was diagnosed more often in the COPD group. At baseline, the culprit lesion was more often restenosis and in-stent thrombosis in the COPD group, whereas de-novo lesion—in the non-COPD group. The rates of periprocedural mortality and myocardial infarction did not differ between the groups with and without COPD (0.13% vs 0.12%, $P = 0.88$ and 0.53% vs 0.45%, $P = 0.39$, respectively). COPD was found to be an independent predictor of restenosis assessed before PCI in patients with a history of PCI ($P = 0.006$).

CONCLUSIONS Patients with COPD diagnosed before PCI are at an increased risk of MVD with or without LMCA involvement and NSTEMI. Restenosis and in-stent thrombosis occur more often in patients with COPD before PCI.

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INTRODUCTION The prevalence of chronic obstructive pulmonary disease (COPD) is estimated at 7.6%, regardless of diagnostic criteria.[1] COPD is projected to rank fifth worldwide in terms of disease burden and third regarding the mortality rate.[2] An increasing body of evidence on the prevalence and distribution of COPD worldwide has become available. However, most data have been derived from expert opinions, and they differ significantly in terms of the population, especially regarding age, concomitant diseases, race, as well as diagnostic criteria of COPD.[3] This

hampers a conclusive comparison of the prevalence of COPD between different countries. The Global Initiative for Chronic Obstructive Lung Disease has established a definition of COPD for epidemiological purposes.[2] Early diagnosis is crucial to encourage smoking cessation, appropriate pharmacotherapy, and physical exercise.[4,5] The diagnosis of COPD increases the risk of and mortality from cardiovascular diseases by an odds ratio of 2.7 and 1.68, respectively.[6] The prevalence of coronary artery disease (CAD) among patients with COPD is estimated at 10% to 23%,[7] while its incidence among patients undergoing PCI—at 2.4% to 10%.[8-11] A study on a group of 119 patients demonstrated that the real prevalence of COPD confirmed by spirometry in hospitalized patients with CAD is 34%, of which 87% had not been not previously diagnosed with COPD.[12] Therefore, the aim of the current study was to assess the impact of COPD on periprocedural outcomes of percutaneous coronary interventions (PCIs) and its relationship with clinical presentation and the type of coronary artery lesions in a large group of patients.

PATIENTS AND METHODS

Study population, design, and definitions

We collected and prospectively analyzed national data on all patients who underwent PCI in Poland between January 2015 and December 2016. Data on PCI procedures were obtained from the Polish registry ORPKI (in Polish, Ogólnopolski Rejestr Procedur Kardiologii Inwazyjnej), which is coordinated nationwide by Jagiellonian University Medical College (Kraków, Poland) in cooperation with the Association of Cardiovascular Interventions of the Polish Cardiac Society.[13,14] Although the ORPKI database is voluntary, the majority of all catheterization laboratories in Poland (98%) record their data in the registry. The Polish database has been continuously upgraded over consecutive years, and in 2016, it reached more than 250 clinical, procedural, and outcome variables, with more than 110 000 new PCI records added each year.

COPD was defined on the basis of a previously established diagnosis.[2] All indices recorded in the ORPKI database are derived from the periprocedural data provided by the operator after each procedure. Furthermore, we did not collect follow-up data after discharge. Periprocedural major adverse cardiac events (MACEs) were defined as the combination of all-cause death, myocardial infarction (MI), and cerebral stroke. The definition of MI was in line with the third universal definition of MI and remained at the descretion of the operator.[15] The Thrombolysis in Myocardial Infarction (TIMI) grade flow was used to estimate procedural TIMI effectiveness, and the treatment was considered effective when the TIMI flow grade 3 was obtained after the procedure. The study protocol was approved by an institutional review board.

Statistical analysis

All continuous variables were evaluated using the Kolmogorov–Smirnov test to confirm normal distribution. Continuous variables were presented as mean (SD) and median (interquartile range). Categorical variables were presented as numeric values and percentages. Continuous variables were compared with the *t* test and the Mann–Whitney test, whereas categorical variables—with the χ^2 test. Univariate and multivariable analyses were performed to identify predictors of restenosis, in-stent thrombosis, and multivessel disease (MVD) with or without the left main coronary artery (LMCA) involvement and separate LMCA disease in all patient groups. Additionally, we analyzed predictors of restenosis and in-stent thrombosis in the subgroup of patients with COPD and a history of PCI. The following variables were analyzed: age, sex, diabetes, previous stroke, MI, PCI, coronary artery bypass grafting (CABG), smoking status, psoriasis, kidney disease, COPD, vascular access, fractional flow reserve, intravascular ultrasound, optical coherence tomography, thrombectomy, rotablation, pharmacological treatment, TIMI flow, contrast and radiation dose, periprocedural complications, clinical presentation of CAD, and the type of coronary artery lesions including distribution, bifurcations, and chronic total occlusions (CTOs). We assessed the same factors for the analysis of the PCI subgroups.

RESULTS

Characteristics of patients with and without chronic obstructive pulmonary disease

We analyzed 221187 PCIs performed in Poland between January 1, 2015, and December 31, 2016. Among all patients who underwent PCI, there were 5594 patients (2.5%) with COPD. The highest incidence of COPD was reported in patients aged between 70 and 80 years (3.4%) and 80 and 90 years (3.3%) (FIGURE 1A). Moreover, the highest incidence was observed in patients with non–ST-segment elevation MI (NSTEMI) presentation of CAD (3.36%), as compared with other clinical presentations (FIGURE 1B). Finally, the highest incidence was noted for patients with separate LMCA involvement (4.06%) and MVD with LMCA involvement (3.55%), as compared with those with single-vessel disease (SVD) and MVD without LMCA involvement (FIGURE 1C). Demographic characteristics, concomitant diseases, and clinical presentation of patients with and without COPD are presented in TABLE 1.

Periprocedural variables

Periprocedural data, including vascular access, pharmacological therapy, and angiographic results, are presented in TABLES 1 and 2. In the COPD group, radial access was more often used in patients with stable angina (SA) (P = 0.02), while it was used less frequently in those with ST-segment elevation MI (STEMI) (P = 0.03). Pharmacological treatment before hospitalization and during PCI is presented in TABLE 2.

FIGURE 1
A – incidence of chronic obstructive pulmonary disease (COPD) according to age;
B – incidence of COPD according to clinical presentation of coronary artery disease before percutaneous coronary intervention;
C – incidence of COPD according to localization of atherosclerotic lesions in coronary arteries
Abbreviations: LMCA, left main coronary artery; MVD, multivessel disease; NSTEMI, non–ST-segment elevation myocardial infarction; SA, stable angina; STEMI, ST-segment elevation myocardial infarction; SVD, single-vessel disease; UA, unstable angina

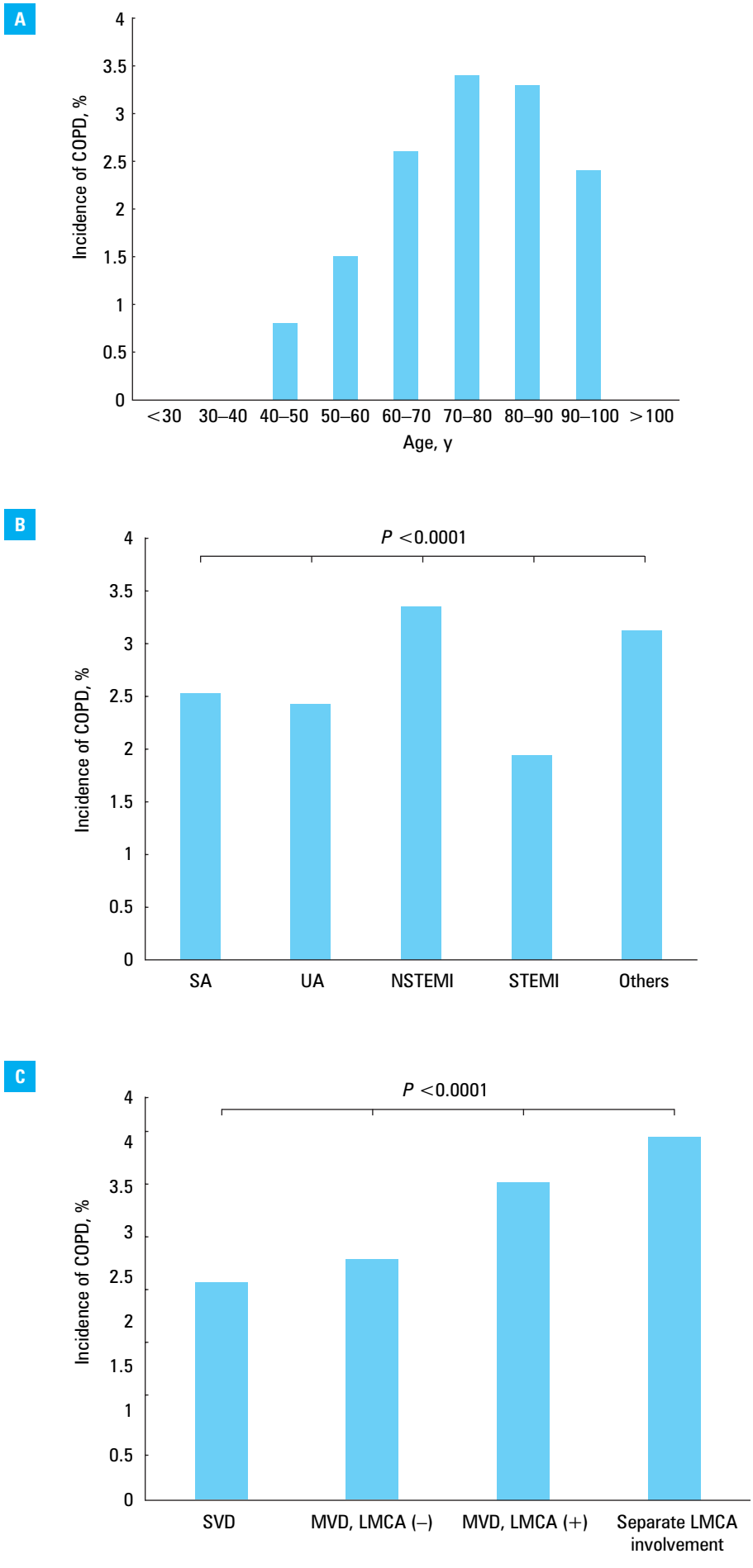

TABLE 1 Baseline demographic and clinical characteristics of the study groups

Parameter		COPD (+) (n = 5594)	COPD (–) (n = 215 593)	*P* value
Age, y	Mean (SD)	70.3 (9.3)	67.0 (10.8)	<0.0001
	Median (IQR)	70 (64–77)	67 (60–75)	
Sex, males		4045/5592 (72.3)	146 095/215 539 (67.8)	<0.0001
Diabetes, n (%)		2041/5594 (36.5)	50 636/215 593 (23.5)	<0.0001
Hypertension		4598/5594 (82.2)	152 810/215 593 (70.9)	<0.0001
Previous cerebral stroke		414/5594 (7.4)	6876/215 593 (3.2)	<0.0001
Previous MI		2103/5594 (37.6)	66 852/215 593 (31.0)	<0.0001
Previous PCI		2126/5594 (38.0)	80 318/215 593 (37.2)	0.25
Previous CABG		405/5594 (7.2)	13 687/215 593 (6.3)	0.007
Smoking status		1888/5594 (33.7)	40 686/215 593 (18.9)	<0.0001
Psoriasis		48/5594 (0.8)	821/215 593 (3.8)	<0.0001
Kidney disease		918/5594 (16.4)	11 209/215 593 (5.2)	<0.0001
Indication for PCI[a]				
Stable angina		1549/5587 (27.7)	59 503/215 269 (27.6)	0.88
Unstable angina		1602/5587 (28.7)	64 115/215 269 (29.8)	0.07
NSTEMI		1384/5587 (24.8)	39 732/215 269 (18.4)	<0.0001
STEMI		994/5587 (17.8)	50 120/215 269 (23.3)	<0.0001
Others		58/5587 (1.0)	1799/215 269 (0.8)	0.1
Vascular access				
Femoral artery		1344/5594 (24.0)	55 292/215 593 (25.6)	0.006
Left radial artery		869/5594 (15.5)	35 910/215 593 (16.6)	0.02
Right radial artery		3323/5594 (59.4)	122 806/215 593 (56.9)	<0.001
Other		58/5594 (1.0)	1585/215 593 (0.7)	0.009

Data are presented as number (percentage) of patients unless otherwise indicated.

Abbreviations: CABG, coronary artery bypass grafting; COPD, chronic obstructive pulmonary disease; IQR, interquartile range; MI, myocardial infarction; PCI, percutaneous coronary intervention; others, see **FIGURE 1**

Specification of the culprit lesion The location of coronary atherosclerosis on angiography is presented in **TABLE 3**. There were 1549 patients with SA diagnosed before PCI in the COPD group (27.7%) and 59 503 patients with SA in the non-COPD group (27.6%). Patients with acute coronary syndrome (ACS) at baseline constituted 71.1% (n = 3980) of the COPD group and 71.3% (n = 153 967) of the non-COPD group.

At baseline, we recorded 1703 de-novo lesions (94.3%), 101 cases of restenosis (5.6%), and 1 case of in-stent thrombosis (0.05%) of the overall 1805 treated lesions among patients with SA presentation of CAD in the COPD group. In the non-COPD group of patients with SA diagnosed before PCI, there were 62 618 de-novo lesions (95.1%), 3192 cases of restenosis (4.8%), and 45 cases of in-stent thrombosis (0.06%). At baseline, the ACS subgroup of patients included 4411 patients with de-novo lesions (94%), 235 patients with restenosis (5%), and 45 patients with in-stent thrombosis (0.9%) in the COPD group, and 160 674 patients with de-novo lesions (94.7%), 7854 patients with restenosis (4.6%), and 1092 patients with in-stent thrombosis (0.6%) in the non-COPD group. The rate of in-stent thrombosis was higher at baseline in the ACS subgroup in comparison with the SA subgroup both in the COPD ($P = 0.001$) and non-COPD groups ($P < 0.001$). The rate of de-novo lesions was higher in patients with SA compared with those with ACS only in the non-COPD group ($P < 0.001$). The subgroups of patients with SA showed no significant differences in the rates of lesion type at baseline between the COPD and non-COPD groups. However, when comparing the ACS subgroups, the non-COPD group showed a higher rate of de-novo lesions ($P = 0.03$) and a lower rate of in-stent thrombosis ($P = 0.008$).

We did not find significant differences in the rates of restenosis depending on the type of procedure (drug-eluting stenting, bare metal stenting, bioresorbable scaffold implantation, plain old balloon angioplasty, and drug-eluting balloon implantation) between the SA and ACS subgroups in the COPD group on admission. In the non-COPD group at baseline, restenosis after drug-eluting stent implantation was reported more frequently in patients with ACS ($P = 0.06$), while restenosis after bare metal stent implantation—in patients with SA ($P = 0.01$). There were also no significant differences in the frequency of a particular type of restenosis in the SA and ACS subgroups of patients between the COPD and non-COPD groups at baseline. Patients with SA underwent more CTO

TABLE 2 Baseline characteristics of the study groups

Parameter		COPD (+) (n = 5594)	COPD (–) (n = 215 593)	*P* value
CTO		267/5594 (4.8)	9053/215 593 (4.2)	0.03
Bifurcation		369/5594 (6.6)	11 525/215 593 (5.3)	<0.0001
FFR		78/5594 (1.4)	3180/215 593 (1.5)	0.62
IVUS		40/5594 (0.7)	1842/215 593 (0.8)	0.26
OCT		7/5594 (0.1)	393/215 593 (0.18)	0.32
Rotablation		29/5594 (0.5)	946/215 593 (0.44)	0.37
Coronary angiography				
SVD		3381/5152 (65.6)	135 320/195 724 (69.1)	<0.0001
MVD, LMCA (–)		1409/5152 (27.3)	50 847/195 724 (26.0)	0.02
MVD, LMCA (+)		288/5,152 (5.6)	7812/195 724 (4.0)	<0.0001
Separate LMCA disease		74/5152 (1.4)	1745/195 724 (0.9)	<0.0001
Pharmacological treatment before hospitalization				
ASA		3255/5594 (58.2)	105 118/215 593(48.7)	<0.0001
UFH		860/5594 (15.4)	31 912/215 593 (14.8)	0.23
LMWH		95/5594 (1.7)	1966/215 593 (0.9)	<0.0001
$P2Y_{12}$ inhibitors	Clopidogrel	3593/5594 (64.2)	118 212/215 593 (54.8)	<0.0001
	Ticagrelor	227/5594 (4.0)	10 907/215 593 (5.0)	<0.001
	Prasugrel	22/5594 (0.4)	1143/215 593 (0.5)	0.23
GP IIb/IIIa inhibitor		455/4672 (9.7)	21 047/176 775 (11.9)	<0.0001
Bivalirudin		0/5594 (0)	17/215 593 (0.003)	0.48
Thrombolysis		1/4677 (0.02)	43/177 114 (0.02)	0.9
Pharmacological treatment during PCI				
ASA		1043/5594 (18.6)	36 511/215 593 (16.9)	<0.001
UFH		5070/5594 (90.6)	181 503/215 593 (84.2)	<0.0001
LMWH		135/5594 (2.4)	8371/215 593 (3.9)	<0.0001
$P2Y_{12}$ inhibitors	Clopidogrel	2426/5434 (44.6)	90 659/215 593 (42.0)	<0.0001
	Ticagrelor	132/5434 (2.4)	10 227/215 593 (4.7)	<0.0001
	Prasugrel	28/5434 (0.5)	973/215 593 (0.4)	0.48
GP IIb/IIIa inhibitors		13/5594 (0.2)	836/215 593 (0.4)	0.06
Bivalirudin		14/5594 (0.2)	556/215 593 (0.2)	0.91
Thrombolysis		8/5594 (0.1)	341/215 593 (0.1)	0.77

Data are presented as number (percentage) of patients.

Abbreviations: ASA, acetylsalicylic acid; CTO, chronic total occlusion; FFR, fractional-flow reserve; GP, glycoprotein; IVUS, intravascular ultrasound; LMWH, low-molecular-weight heparin; OCT, optical coherence tomography; UFH, unfractionated heparin; others, see **FIGURE 1** and **TABLE 1**

procedures (5.9% vs 4.3%, *P* = 0.01), bifurcations (7.9% vs 6.1%, *P* = 0.01), and rotablations (1.2% vs 0.3%, *P* <0.001) compared with those with ACS. At baseline, patients with ACS underwent PCI of the LMCA more often (5.2% vs 3.5%, *P* = 0.007) than those with SA. PCIs of CTO and bifurcated lesions was performed more often in men than in women (5.3% vs 3.4%, *P* = 0.002 and 7.2% vs 5.0%, *P* = 0.002, respectively), while thrombectomy occurred more often in women than in men (2.2% vs 3.4%, *P* = 0.01). PCIs of the LMCA and circumflex artery (Cx) were performed more often in patients with NSTEMI, while of the right coronary artery—in patients with STEMI (*P* <0.001). Bifurcations were treated with PCI more frequently in the MVD group compared with the SVD group (*P* <0.001). PCI of the LMCA, left anterior descending artery, and Cx were performed more often in the MVD group, whereas PCI of the right coronary artery was more frequent in the SVD group (*P* <0.001). Periprocedural indices, including the type of the culprit lesion, PCI procedure, and stent according to the location, are presented in **TABLE 3**.

After adjustment for the type of an implanted stent, there were no significant differences in the restenosis rate assessed before stent implantation between the COPD and non-COPD groups in the subgroups undergoing drug-eluting stent, bare metal stent, or bioresorbable scaffold implantation. However, we observed higher restenosis rates assessed before PCI in patients undergoing plain balloon angioplasty or drug-eluting balloon angioplasty when performed on the Cx (60% vs 28.5%, *P* = 0.03).

TABLE 3 Culprit lesion type according to localization in patients with and without chronic obstructive pulmonary disease

Location	Total number of lesions			De novo			Restenosis			In-stent thrombosis		
	COPD (+)	COPD (–)	*P* value	COPD (+)	COPD (–)	*P* value	COPD (+)	COPD (–)	*P* value	COPD (+)	COPD (–)	*P* value
Overall	6542 (100)	237 956 (100)	–	6153 (94.0)	225 647 (94.8)	0.005	341 (5.2)	11 137 (4.7)	0.04	48 (0.7)	1172 (0.5)	0.006
RCA	2164 (33.1)	77 854 (32.7)	0.53	2005 (32.6)	73 392 (32.5)	0.91	133 (39)	4086 (36.7)	0.38	26 (54.2)	376 (32.1)	0.001
LMCA	268 (4.1)	6429 (2.7)	<0.0001	256 (4.2)	6132 (2.7)	<0.0001	11 (3.2)	271 (2.4)	0.35	1 (2.0)	26 (2.2)	0.95
LAD	2268 (34.7)	89 140 (37.5)	<0.0001	2150 (34.9)	84 613 (37.5)	<0.0001	108 (31.7)	4005 (36.0)	0.1	10 (20.8)	322 (27.5)	0.31
Cx	1676 (25.6)	58 190 (24.4)	0.03	1592 (25.9)	52 876 (23.4)	<0.0001	75 (22.0)	2253 (20.2)	0.42	9 (18.7)	209 (17.8)	0.87
IM	81 (1.2)	3367 (1.4)	0.22	81 (1.3)	3209 (1.4)	0.48	3 (0.9)	139 (1.2)	0.54	0 (0)	19 (1.6)	0.37
SvG	71 (1.1)	2545 (1.0)	0.9	60 (1.0)	2171 (1.0)	0.91	10 (2.9)	354 (3.2)	0.79	1 (2.0)	20 (1.7)	0.83
LIMA/ RIMA	11 (0.2)	431 (0.2)	0.8	9 (0.1)	402 (0.2)	0.55	1 (0.3)	29 (0.3)	0.9	1 (2.0)	0 (0)	<0.0001

Data are presented as number (percentage) of patients.

Abbreviations: Cx, circumflex artery; IM, intermediate artery; LAD, left anterior descending artery; LIMA, left internal mammalian artery; RCA, right coronary artery; RIMA, right internal mammalian artery; SvG, saphenous vein graft; others, see FIGURE 1, TABLE 1, and TABLE 2

Periprocedural outcomes At baseline, there were more patients with TIMI flow grade 0 (18% vs 21%, P <0.001) and 1 (12.3% vs 13.5%, P = 0.007) in the non-COPD group compared with the COPD group, while the number of patients with TIMI flow grade 3 was lower (51.0% vs 46.5%; P <0.001). The percentage of patients with an occluded coronary artery at baseline (TIMI flow grades 0 and 1) was higher in the non-COPD group compared with the COPD group (34.5% vs 30.1%, P <0.001).

Although the proportion of patients with TIMI flow grade 3 before PCI was higher in the COPD group (51% vs 46.5%, P <0.001), the frequency of postprocedural TIMI flow grade 3 was higher in the non-COPD group (92.6% vs 94%; P <0.001), indicating a greater effectiveness of PCI (Δ = 47.5% in the non-COPD group and Δ = 41.6% in the COPD group). We also demonstrated that blood flow restoration assessed as TIMI flow grade 3 after the procedure was more common in patients with PCI of the left anterior descending artery (P = 0.001), mainly the proximal segment (P = 0.007) and Cx (P = 0.01), compared with the other arteries. Additionally, PCI effectiveness, expressed as the achievement of TIMI flow grade 3 after the procedure, was higher in patients with SA at baseline compared with those with ACS (97.8% vs 91.8%, P <0.001). It was also better in the NSTEMI group as compared with the STEMI group (88.1% vs 92.2%, P = 0.001).

The periprocedural mortality rate was similar between the COPD and non-COPD groups (0.53% vs 0.45%, P = 0.39). Also, the rate of periprocedural MI did not differ between the COPD and non-COPD groups (0.13% vs 0.12%, P = 0.88).

Clinical presentation of coronary artery disease before percutaneous coronary intervention Considering the clinical presentation of CAD before PCI, the number of patients with NSTEMI was higher than that of patients with STEMI in the COPD group. There were no significant differences in the frequency of SA and unstable angina between the COPD and non-COPD groups (TABLE 1).

Predictors of restenosis and in-stent thrombosis The results of the multivariable analysis of predictors of restenosis and in-stent thrombosis performed for the whole study group are presented in FIGURES 2 and 3. The results of the multivariate analysis for the subgroup of patients with a history of PCI are presented in FIGURE 4A and 4B.

Predictors of multivessel disease To analyze the risk factors for the distribution of atherosclerotic lesions in the coronary arteries, we divided all patients into the groups of patients with SVD and those with MVD with or without LMCA involvement and separate LMCA involvement. The multivariable analysis of the predictors of atherosclerotic lesion distribution in the coronary arteries is presented in FIGURE 5.

DISCUSSION The main finding of our study is that the incidence of COPD in patients undergoing PCI in Poland is 2.5% ; however, this result is likely to be underestimated. We also confirmed that patients with COPD have an increased incidence of proatherosclerotic risk factors. The third finding is that patients with COPD were characterized by an increased level of restenosis, in-stent thrombosis, and NSTEMI as a clinical presentation of CAD at baseline. The multivariable analysis confirmed that COPD was an independent

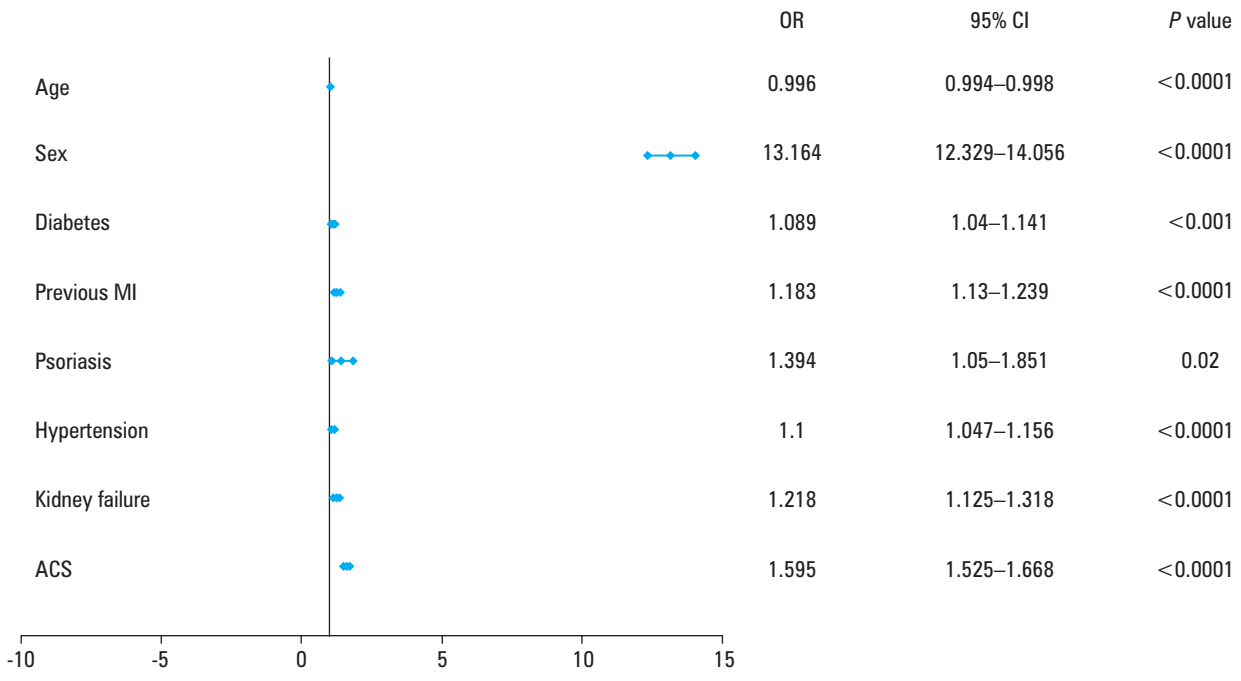

FIGURE 2 Predictors of in-stent thrombosis in patients referred for percutaneous coronary intervention on admission
Abbreviations: ACS, acute coronary syndrome; CI, confidence interval; OR, odds ratio; others, see **TABLE 1**

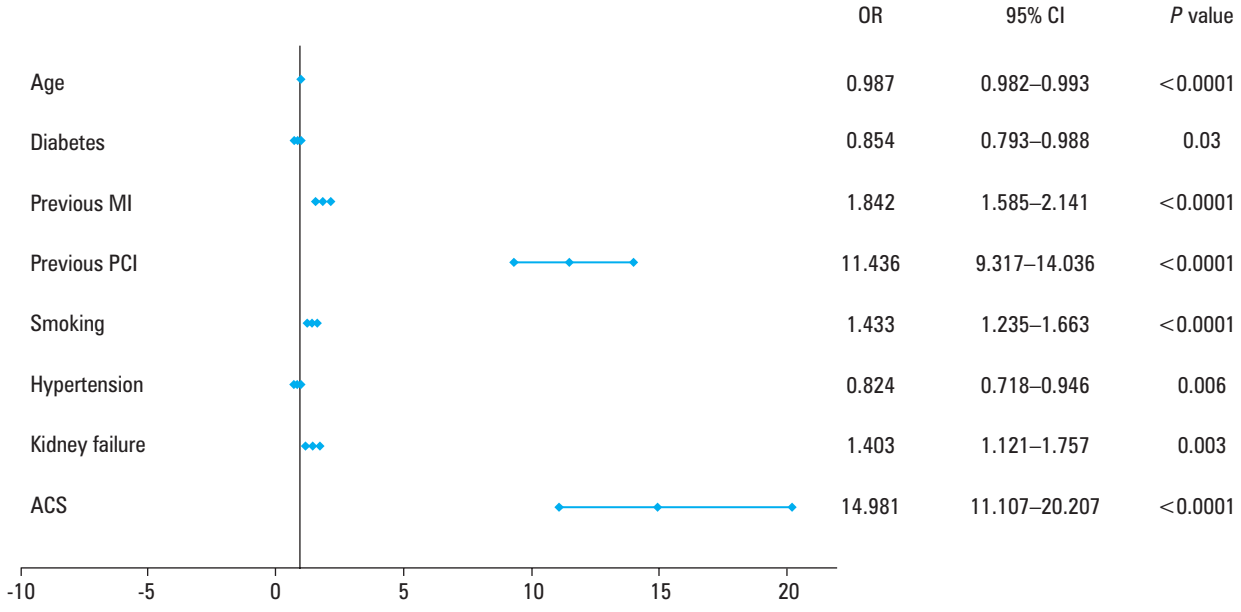

FIGURE 3 Predictors of restenosis in patients referred for percutaneous coronary intervention on admission
Abbreviations: PCI, percutaneous coronary intervention; others, see **TABLE 1** and **FIGURE 2**

predictor of an increased risk of restenosis in patients who had undergone PCI in the past or are currently referred for PCI, irrespective of the clinical presentation. Despite this, patients with COPD were initially more likely to be treated with aspirin, clopidogrel, and low-molecular-weight heparin. Additionally, MVD with or without LMCA involvement and separate LMCA involvement was diagnosed in patients with COPD more often compared with those without COPD. The effectiveness of PCI procedures in the overall group of patients undergoing PCI, assessed as the achievement of TIMI flow grade 3 after the procedure, was significantly higher in the non-COPD group compared with the COPD group.

Incidence of chronic obstructive pulmonary disease and general characteristics of these patients A meta-analysis of studies on the general population, published between 1990 and 2004 and regarding the prevalence of COPD, revealed geographical disparities and differing methodologies.[16] The prevalence of COPD was estimated at 7.6%, independently of the defined diagnostic criteria.

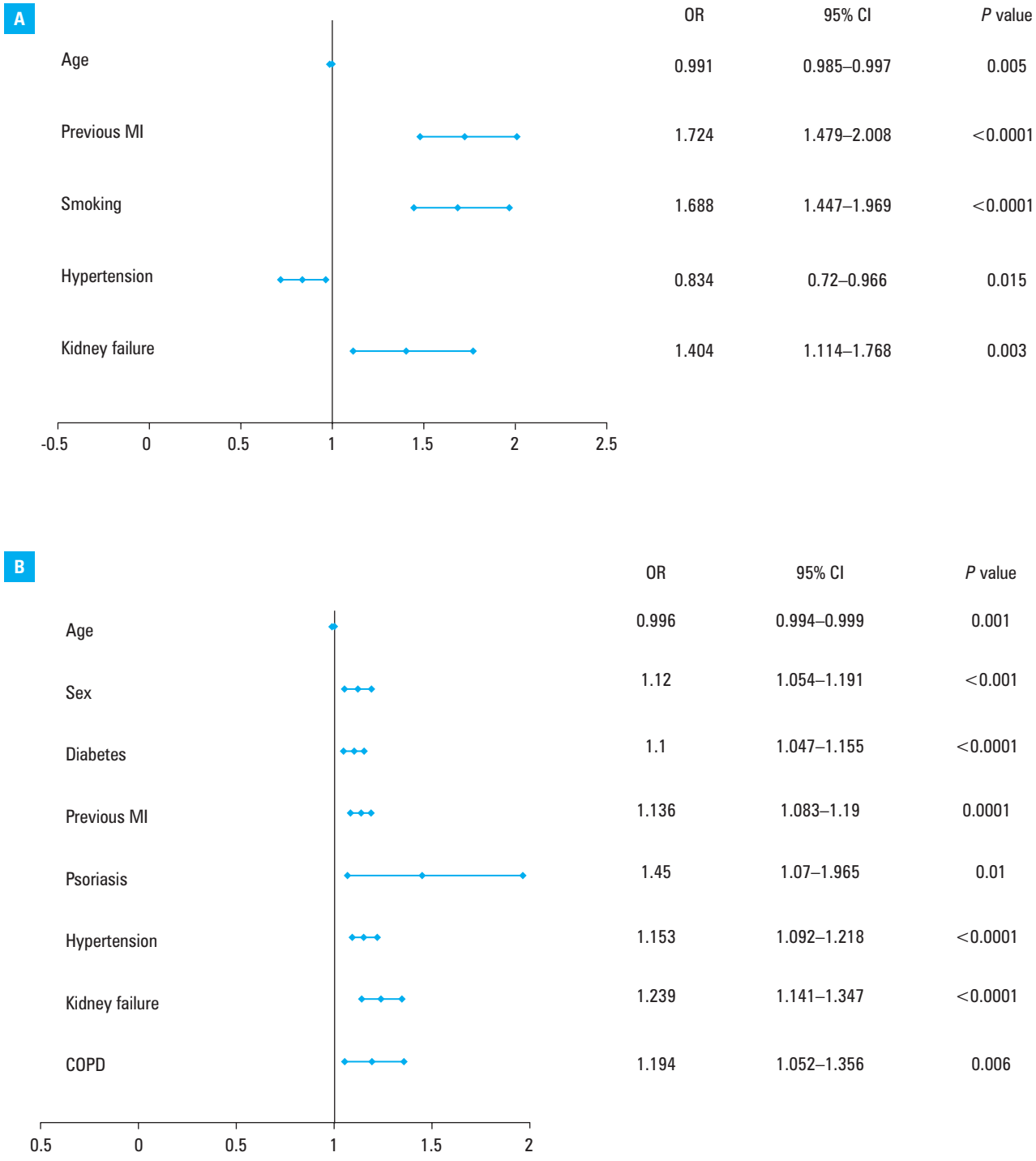

FIGURE 4 Multivariable analysis of restenosis and in-stent thrombosis predictors in patients with a history of percutaneous coronary intervention (PCI) who were referred for PCI on admission; **A** – predictors of in-stent thrombosis; **B** – predictors of restenosis
Abbreviations: see **TABLE 1** and **FIGURE 2**

The prevalence of COPD increases with age.[17] In a retrospective study, in which COPD was identified by the International Classification of Diseases codes, the rate of COPD was 7.17% among patients undergoing PCIs.[18] It was demonstrated that the incidence of COPD varied between 2.4% and 10% in patients with SA, and between 5.3% and 15.6% in patients with ACS.[9,11,18-24] Patients with COPD treated with PCI showed a higher number of comorbidities and more often suffer from CAD.[25] They were also found to have higher mortality rates, higher rehospitalization rates, and poorer health status 1 year after MI.[11,25] These outcomes were attributed to the lower rates of guideline therapies prescribed at discharge.[25] The current results may be connected with a poorer awareness of smokers about the causes of their shortness of breath and therapeutic possibilities. Moreover, patients referred for PCI on admission often try to consciously conceal the signs of pulmonary diseases or diseases connected with smoking, such as COPD, as they fear the disapproval

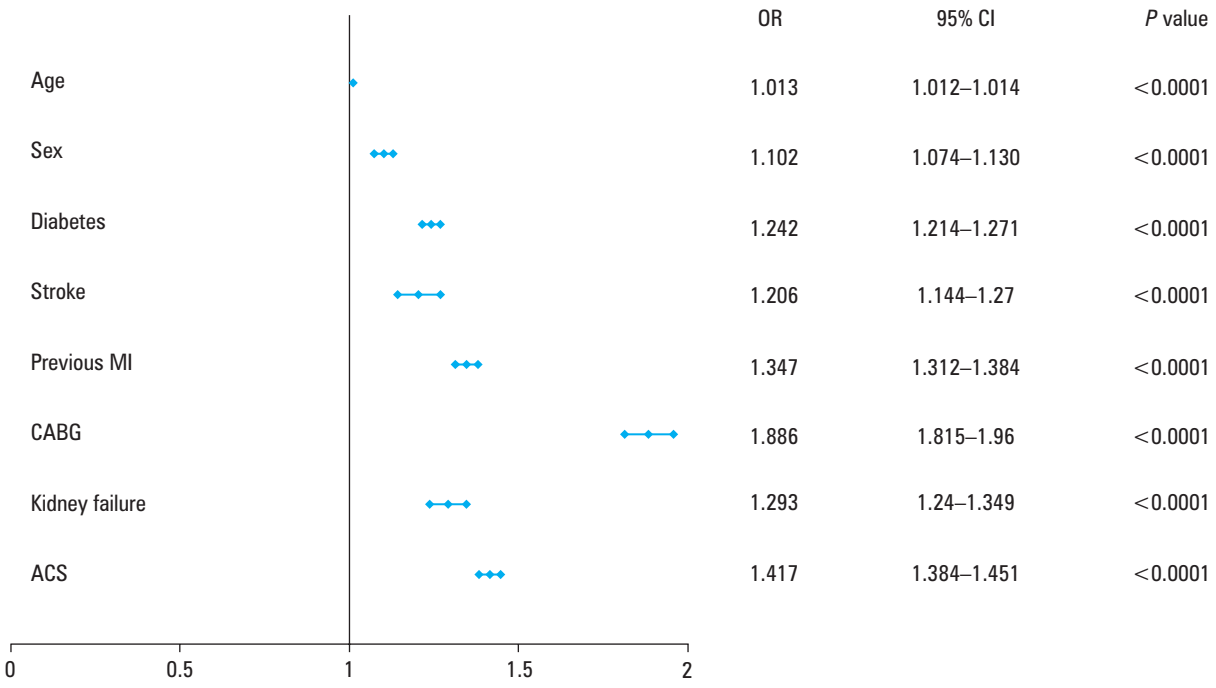

FIGURE 5 Multivariable analysis of predictors of multivessel disease with and without left main coronary artery involvement and separate left main coronary artery in patients referred for percutaneous coronary intervention on admission
Abbreviations: Abbreviations: see **TABLE 1** and **FIGURE 2**

of the treating cardiologist. In conclusion, 2 issues should be highlighted as the main reason for the relatively low incidence of COPD in this group of patients, namely, low compliance of patients and insufficient awareness of the problem among physicians dealing with those patients in invasive cardiology units.

Culprit artery characterization and increased risk of repeat percutaneous coronary intervention

The current study confirmed that patients with COPD are characterized by greater risk of disseminated coronary atherosclerosis. The Gensini score increases in patients with a more advanced stage of COPD and is the highest at stage D.[26,27] Additionally, we noted that patients with COPD presented significantly higher rates of re-stenosis and in-stent thrombosis, while those rates were lower in the case of de-novo culprit lesions before the PCI procedure. Similar observations were reported by Enriquez et al,[25] who noted that patients with COPD had a 30% higher risk of death and a 20% increased risk of undergoing repeat revascularization 1 year after PCI. The most reasonable explanation seems to be the increased number of smokers among patients with COPD and other proatherosclerotic risk factors. Apart from the fact that more cigarette smokers were found among patients with COPD, the disease itself is considered to be a prothrombotic state and may therefore increase the risk of restenosis and in-stent thrombosis.[28] In general, cigarette smoking is considered to be associated with the progression of CAD and restenosis following PCI. However, studies on patients with CAD have reported conflicting results.[29-32] Similar results were described in patients with restenosis after carotid artery stenting.[33] One of the possible explanations is that smokers have a reduced sensitivity to restenosis, and the second is that smokers are more reluctant to seek medical attention despite recurrent angina.[34] The effect of smoking on MACEs is also controversial. Some investigators found that smoking increases the risk of MACEs, while others did not.[35-38]

Another explanation of the increased rate of restenosis and in-stent thrombosis could be inadequate cardiac therapy due to poor compliance, as well as pulmonary therapy due to underdiagnosis resulting in hypoxia and further consequences leading to progression of atherosclerosis. Enriquez et al[25] demonstrated that patients with COPD were significantly less likely to receive β-blockers, aspirin, and statins at discharge after PCI. Since our registry does not include such data, we were unable to conduct this analysis. It was also reported that patients with COPD and ACS frequently show atypical presentation (mainly dyspnea) that could be misinterpreted as COPD exacerbations.[24] In addition, although COPD was associated with an older age and a worse cardiovascular risk profile, it was not independently associated with increased in-hospital mortality rates. However, it was linked to a higher incidence of chronic heart failure.[9] The clinical presentation may be attributed to a specific distribution of atherosclerosis and predominance of NSTEMI as a clinical presentation of CAD, which was confirmed in the present study. It was recently demonstrated that patients with an NSTEMI

presentation of CAD on admission were more often diagnosed with MVD of the coronary arteries compared with patients with STEMI.[39]

Periprocedural effectiveness In the current study, the periprocedural effectiveness assessed by the TIMI flow grade was poorer in patients with COPD compared with those without COPD. It was mainly related to the type of atherosclerosis. In the COPD group, we noticed a higher rate of MVD and LMCA disease as compared with the non-COPD group. Additionally, the main clinical presentation in the COPD group was NSTEMI, whereas the STEMI rate was higher in the non-COPD group. Furthermore, the higher rate of restenosis and in-stent thrombosis on admission in the COPD group negatively affected the effectiveness rate assessed by the TIMI score.

Limitations The ORPKI database does not specifically define restenosis and in-stent thrombosis, and the definitions are usually at the discretion of the operators. No independent angiographic core laboratory analysis was performed. The diagnosis of COPD was based on the previous diagnosis and was not updated by spirometry; however, on the other hand, it reflects the real incidence of COPD in the analyzed group of patients in the Polish population. The other significant limitation of the study is the lack of in-hospital perioperative care and follow-up data, which substantially decreases the quality of the study. However, we were unable to collect those data because we did not have access to patients' identification documents.

Conclusions Patients undergoing PCI are at an increased risk of disseminated atherosclerosis and LMCA involvement in comparison with individuals without COPD. Restenosis and in-stent thrombosis are more common, whereas de-novo lesions are less common in patients with COPD referred for PCI, as compared with those without COPD. COPD is an independent predictor of restenosis in patients with a history of PCI and currently referred for PCI. Coronary atherosclerosis in patients with COPD is more disseminated and tends to involve the LMCA more often when compared with patients without COPD. Patients with suspected COPD who are hospitalized in invasive cardiology units should receive special care in terms of the diagnosis and treatment of COPD, which may improve their long-term results after PCI in the future.

CONTRIBUTION STATEMENT RJ had full access to the data and takes responsibility for the integrity and accuracy of the data and analysis. DD and SB substantially contributed to the study design and assisted as scientific supervisors in the preparation of the manuscript. RJ, AD, and ZS substantially contributed to the study design, data analysis and interpretation, as well as writing of the manuscript. TR substantially contributed to the preparation and writing of the manuscript.

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