



# The role of neighbourhood-level sociodemographic and socioeconomic characteristics on the physical activity of people with COPD

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This study reveals that neighbourhoods with a higher percentage of older adults promote physical activity among people with COPD, while a greater presence of non-EU15 immigrants is associated with reduced activity levels <https://bit.ly/4llxcdu>

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## Abstract

**Background** Physical activity is crucial in slowing COPD progression and reducing mortality, yet the influence of the neighbourhood's sociodemographic and socioeconomic environment on it remains unexplored. Our aim is to assess the relationship between these neighbourhood characteristics and physical activity in people with COPD.

**Methods** We analysed cross-sectional data from 407 COPD participants from primary care and hospitals of five Catalan municipalities. We obtained neighbourhood percentages of sociodemographic (older adults and non-EU15 immigrants) and socioeconomic (illiteracy, unemployment and households in poor-conditioned buildings) characteristics from the Spanish Urban Vulnerability Atlas. Over 1 week, we tracked steps per day, time spent in physical activity of any intensity, moderate-to-vigorous physical activity (MVPA) and sedentary time using an activity monitor

**Results** After adjusting for age, sex, marital status, social class, road traffic noise levels and PM<sub>2.5</sub> in multivariable linear regression models, each 10% increase in the neighbourhood percentage of older adults was associated with 922 (95% CI: 84–1759) more steps per day and 11 (1 to 20) more minutes per day in MVPA. Each 10% increase in the neighbourhood percentage of non-EU15 immigrants was associated with fewer steps per day (–332; 95% CI: –647 to –16), fewer minutes per day in physical activity of any intensity (–5; 95% CI: –11 to 0) and fewer minutes per day in MVPA (–5; 95% CI: –7 to 0). No associations were found between neighbourhood socioeconomic characteristics and physical activity.

**Conclusion** A neighbourhood's percentages of older adults and non-EU15 immigrants are associated with physical activity of COPD patients.

## Introduction

Maintaining higher levels of physical activity is essential for people with COPD, as it attenuates lung function decline [1] and reduces the risks of hospitalisations and death [2]. Most research on what



influences physical activity in people with COPD has focused on individual clinical, lifestyle and sociodemographic characteristics [2]. However, ecological models suggest that wider environmental aspects such as neighbourhood attributes also play a role in shaping a person's decision to engage in physical activity [3].

Recent studies suggested that neighbourhood *physical* characteristics affect physical activity levels in people with COPD. For instance, longer pedestrian streets have been associated with more steps [4], while higher levels of outdoor air pollutants have been linked to fewer steps, less time in moderate-to-vigorous physical activity (MVPA) and more sedentary time [5, 6]. Unfortunately, research on the effects of the neighbourhood *social* environment remains limited, and their results are inconclusive. One study found that densely populated neighbourhoods were associated with fewer steps and more sedentary time in COPD [7]. Two studies reported that neighbourhood urban vulnerability, assessed by local indexes, was not related to physical activity in COPD participants, but the individual components of such vulnerability indexes were not analysed [7, 8]. This leaves a gap in understanding how neighbourhood sociodemographic and socioeconomic characteristics influence the physical activity levels in people with COPD.

Based on previous quantitative and qualitative research in adults and older adults [9–13], we hypothesised that specific neighbourhood sociodemographic factors (percentages of older adults and non-EU15 immigrants) and socioeconomic factors (percentages of illiterate and unemployed population and the percentage of households in poor-conditioned buildings) may be related to physical activity in people with COPD. Therefore, this study aimed to examine the association between these neighbourhood characteristics and objectively measured physical activity in individuals with mild-to-very severe COPD.

## Methods

### Study design and population

This cross-sectional study used pre-randomisation baseline data from the Urban Training Study (NCT01897298) [14]. From October 2013 to February 2015, we identified people with COPD diagnosed according to the guidelines of the American Thoracic Society and the European Respiratory Society (ATS/ERS) [15], at 33 primary care centres and five tertiary hospitals in five Catalan municipalities: Barcelona, Badalona, Mataró, Viladecans and Gavà. We purposefully selected diverse settings and geographical locations to enhance generalisability (by maximising variability in patient demographics, clinical practices and environmental factors), reduce selection bias (as a single-centre study may reflect local patient characteristics or treatment practices) and minimise confounding (as the distribution of unmeasured confounders is likely to differ across sites). We excluded those who: 1) spent over 3 months annually away from their registered residence; 2) were diagnosed with significant mental impairment or severe psychiatric conditions; and 3) had severe comorbidities with a prognosis of <1 year's life expectancy. From 410 included participants, we excluded those with no data on neighbourhood-level characteristics (n=3), yielding 407 participants for the present study. The Ethics Committees of all involved institutions approved the study, and all participants provided written informed consent.

### Variables and instruments

#### Neighbourhood-level characteristics

We acquired the participants' neighbourhood-level characteristics from the 2011 edition of the Spanish National Census via the Urban Vulnerability Atlas (UVA) [16], using their geocoded addresses. We obtained: 1) sociodemographic characteristics (percentage of older adults ( $\geq 75$  years) and percentage of immigrants from non-EU15 countries (from outside the first 15 European Union member states)); and 2) socioeconomic characteristics (percentage of unemployed, percentage of illiterate population and percentage of households in poor-conditioned buildings (state of ruin, poor or deficient condition)). Lastly, we obtained the neighbourhood crime perception (percentage of households that believed they were affected by crime) from the 2001 edition of the UVA. Owing to its subjective nature, this variable was included only in secondary analyses.

#### Physical activity

We obtained objective physical activity measurements using the Dynaport activity monitor (McRoberts, The Hague, The Netherlands), validated for people with COPD [17]. Trained staff instructed participants to wear the activity monitors at the centre of their lower back using an elastic strap for 1 week. We considered measurements valid if participants wore the activity monitor for at least 8 h per day during waking hours (07:00 to 22:00) on at least 3 days [18]. All participants met this criterion, with a median (P25–P75) wearing time of  $14.9 \text{ h} \cdot \text{day}^{-1}$  (1.1–15) of 15 possible hours. Additionally, the median (IQR) wear duration was 7 days (4–7), and all participants included at least one weekend day at baseline. We

obtained the mean steps per day, time spent in physical activity at any intensity (minutes per day at  $>1.5$  metabolic equivalent task (METs)), time spent in MVPA (minutes per day at  $\geq 3$  METs) and sedentary time (combined hours per day of lying and sitting). Other physical activity variables, such as time spent in light-intensity physical activity or average intensity during locomotion, were not included in the analysis, as they were considered redundant based on previous research with this sample [4, 7]. Additionally, given the minimal variability in wearing time, this variable was also excluded from the analysis.

#### *Other relevant participants' information*

Interviewer-administered validated questionnaires provided data on: 1) individual sociodemographic characteristics, including age, sex, education, marital status, number of people living at home, working status and occupation (which allowed estimating individual socioeconomic status (SES) using the National Statistics Socioeconomic Classification, which consists of six categories: I, professional; II, managerial and technical; IIIN, skilled non-manual; IIIM, skilled manual; IV, partly skilled; and V, unskilled occupations); 2) smoking history (status, intensity and duration); and 3) and perceived difficulty with physical activity, through the Clinical visit version of the PROactive physical activity in COPD (C-PPAC instrument) [19].

We also obtained the post-bronchodilator forced expiratory volume in 1 s ( $FEV_1$ ) and forced vital capacity from standardised spirometry [20], and 6-minute walking distance (6MWD) from the standardised 6-minute walking test [21]. We additionally obtained data on environmental exposures, including annual average levels of particulate matter (particles with a 50% cut-off aerodynamic diameter of  $2.5 \mu\text{m}$  ( $PM_{2.5}$ )) and road traffic noise, by linking participants' geocoded addresses with land-use regression models [22] and the 2012 Barcelona strategic noise map [23], respectively

#### *Statistical analysis*

Owing to the fixed sample size determined by the Urban Training study's primary objectives [14], we assessed our statistical power to detect significant differences in physical activity across neighbourhoods with different socioeconomic characteristics. Based on previous data about the distribution of neighbourhood deprivation [24] and the distribution of physical activity levels in our sample, 407 patients would allow detecting a difference equal to or higher than the minimal important difference of steps in COPD ( $1100 \text{ steps}\cdot\text{day}^{-1}$ ) [25] between the least and the most deprived neighbourhoods, with a statistical power of 78%. For this calculation, we used the GRANMO 8.0 software [26].

To assess how neighbourhood sociodemographic and socioeconomic characteristics relate to physical activity, we built a separate multivariable linear regression model for each physical activity outcome. All neighbourhood-level variables were included as exposures, and confounders were added as covariates. These confounders—age, sex, marital status, social class, road traffic noise levels and  $PM_{2.5}$ —were identified using directed acyclic graphs (DAGs) informed by expert knowledge and existing literature (supplementary figure S1). We checked regression diagnostics, including linearity, normality, homoscedasticity, multicollinearity (variance inflation factor  $<3$ ) and influential observations.

As secondary analyses, we: 1) explored whether neighbourhood characteristics had different effects on physical activity among participants with Global Initiative for Chronic Obstructive Lung Disease (GOLD) I–II and GOLD III–IV severity levels by stratifying the sample accordingly and calculating the p-value of the interaction term; and 2) indirectly assessed the potential mediating role of perceived difficulty with physical activity, and neighbourhood crime perception in the observed associations, one variable at a time.

As sensitivity analyses, we tested the robustness of our findings to diverse assumptions by: 1) repeating the models excluding extreme values ( $< 5$ th and  $>95$ th percentile) in exposure variables to mitigate the influence of outliers; and 2) using mixed models, including the recruitment centre as a random effect to account for potential neighbourhood similarities in participants from the same recruitment centre.

We performed a complete case analysis using R version 4.0.3 ([www.r-project.org/](http://www.r-project.org/)).

## **Results**

### *Sample characteristics*

Participants were mostly male (85%), and had a mean $\pm$ SD age of  $69\pm 8$  years (table 1). They had mild-to-very severe COPD (mean  $FEV_1$   $57\pm 18\%$  predicted) and showed a preserved functional exercise capacity with a 6MWD of  $486\pm 95$  m. Participants were generally physically active (mean  $7547\pm 4045 \text{ steps}\cdot\text{day}^{-1}$ , and  $106\pm 48 \text{ min day}^{-1}$  spent in MVPA). They also spent most of their time on sedentary activities ( $10.4\pm 1.6 \text{ h}\cdot\text{day}^{-1}$ ). Regarding neighbourhood-level characteristics, median percentages of older adults, non-EU15 immigrants, unemployed and illiterate were 9%, 16%, 25% and 10% of the

**TABLE 1** Individual-level sociodemographic, clinical and functional, and neighbourhood-level sociodemographic and socioeconomic characteristics in people with COPD (n=407)

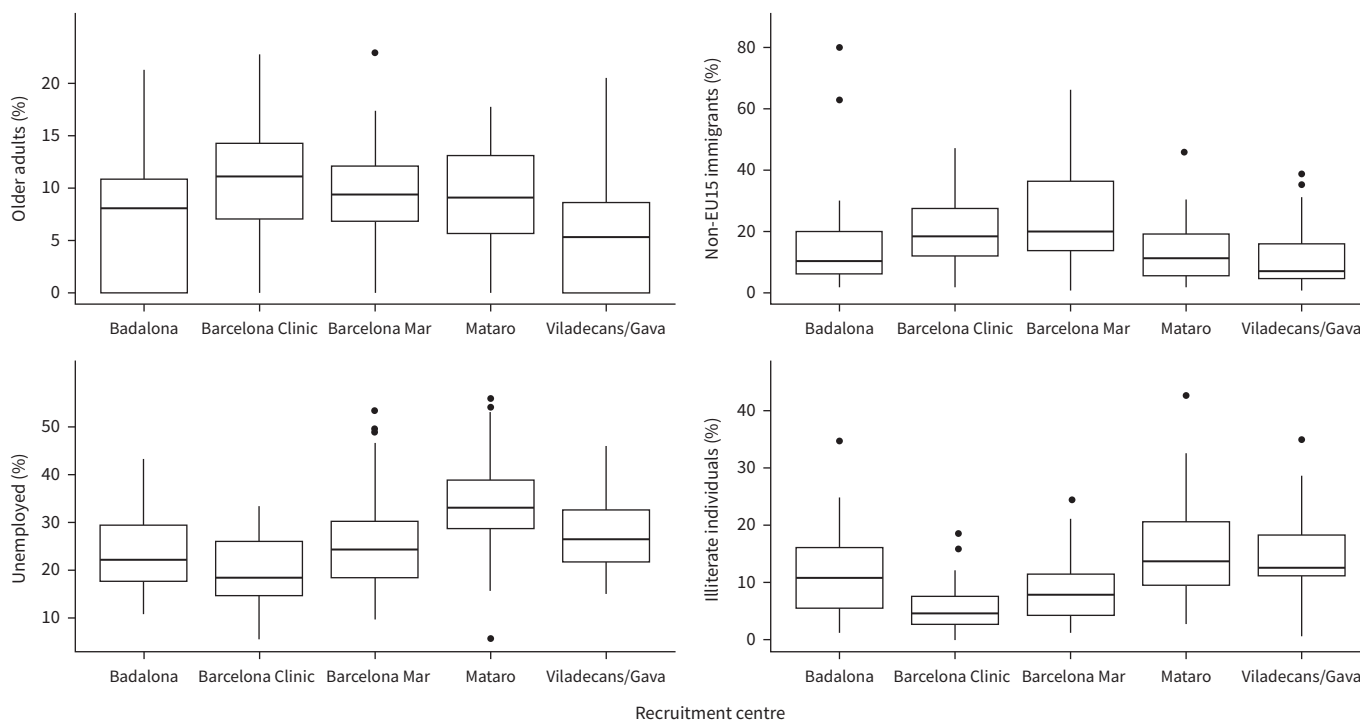
All COPD patients	
<b>Demographics and clinical features</b>	
Age years	69±8
Sex, male	346 (85%)
Studies: high school/university	123 (30%)
Marital status: married	309 (76%)
Working status: working	52 (13%)
Low social class: IIIM–IV–V	291 (72%)
Smoking status: current	98 (24%)
Cardiovascular disease	254 (62%)
Diabetes mellitus	114 (28%)
Musculoskeletal disease	154 (37%)
FEV <sub>1</sub> % pred	57±18
GOLD severity: GOLD I–II	256 (63%)
Dyspnoea (mMRC grade, 0–4)	1 (1–2)
6-min walking distance m	486±95
C-PPAC difficulty score (0 worse to 100 better)	82±15
<b>Physical activity variables</b>	
Mean steps·day <sup>-1</sup>	7547±4045
Time in physical activity of any intensity min·day <sup>-1</sup>	169±71
Time in moderate-to-vigorous physical activity min·day <sup>-1</sup>	106±48
Sedentary time h·day <sup>-1</sup>	10.4±1.6
<b>Environmental variables</b>	
PM <sub>2.5</sub> µg·m <sup>-3</sup>	12.24±1.99
Road traffic noise (L <sub>den</sub> , dB)	63±6
<b>Neighbourhood-level characteristics</b>	
Older adults %	9 (5–13)
Non-EU15 immigrants %	16 (6–22)
Unemployed %	25 (19–32)
Illiterate %	10 (6–15)
Households in poor-conditioned buildings %	3 (0–13)
Neighbourhood crime perception %	26 (18–45)
Data are presented as mean±sd, n (%) and median (IQR). Some variables have missing values: 1 in Studies; 1 in Marital status; 2 in Social class; 96 in C-PPAC difficulty score; 3 in PM <sub>2.5</sub> ; 4 in Road traffic noise; 5 in Older adults; 30 in Non-EU15 immigrants; 7 in Unemployed; 3 in Illiterate; 3 in Households in poor-conditioned buildings; 42 in Neighbourhood crime perception. FEV <sub>1</sub> : forced expiratory volume in 1 s; GOLD: Global Initiative for Chronic Obstructive Lung Disease; mMRC: modified Medical Research Council Questionnaire; C-PPAC: clinical visit version of the PROactive Physical Activity in COPD; PM <sub>2.5</sub> : particulate matter of ≤2.5 µm in diameter.	

population, respectively, with significant differences observed across recruitment centres (figure 1). Owing to the low proportion of neighbourhood percentage of households in poor-conditioned buildings (median 3%), we excluded this variable from further analyses (table 1).

### Neighbourhood percentage of older adults

In the overall sample, after adjusting for age, sex, marital status, social class, road traffic noise levels and PM<sub>2.5</sub>, each 10% increase in the neighbourhood percentage of older adults was significantly associated with more steps per day (922 steps·day<sup>-1</sup>, 95% CI: 84–1759) and more minutes per day spent in MVPA (11 min·day<sup>-1</sup>, 95% CI: 1–20) (figure 2, table 2). There was no significant association between the percentage of older adults and time spent in physical activity of any intensity or sedentary time.

After stratifying by GOLD stages, the previously observed associations with steps per day and time spent in MVPA were stronger for GOLD I–II while they disappeared for GOLD III–IV (figure 2, table 2). In addition, a statistically significant relationship appeared between the percentage of older adults and more physical activity of any intensity as well as less sedentary time in GOLD I–II but not in GOLD III–IV. There was evidence of statistical interaction between the percentage of older adults and GOLD stage for all four physical activity variables (figure 2, table 2). Statistically significant differences are indicated by asterisks when p-for-interaction is below 0.05 in figure 2, and the magnitude of association estimates for each GOLD stage are detailed in table 2.



**FIGURE 1** Distribution of neighbourhood-level sociodemographic and socioeconomic characteristics across the recruitment centres. Box central line and whiskers indicate median and IQR. Sample sizes for each recruitment centre: Badalona (n=28), Barcelona Clinic (n=79), Barcelona Mar (n=108), Mataró (n=73), Viladecans/Gavà (n=119).

After adjusting for perceived difficulty with physical activity, the associations found in the main analysis lost statistical significance (figure 3, supplementary table S1), while they were not affected after adjusting for neighbourhood crime perception.

#### Neighbourhood percentage of non-EU15 immigrants

In the overall sample, after adjusting for potential confounders, each 10% increase in the neighbourhood percentage of non-EU15 immigrants was statistically significantly associated with fewer steps per day ( $-332 \text{ steps}\cdot\text{day}^{-1}$ , 95% CI:  $-647$ – $-16$ ), fewer minutes spent in physical activity of any intensity ( $-5 \text{ min}\cdot\text{day}^{-1}$ , 95% CI:  $-11$ – $0$ ) and fewer minutes in MVPA ( $-4 \text{ min}\cdot\text{day}^{-1}$ , 95% CI:  $-7$ – $0$ ). The neighbourhood percentage of non-EU15 immigrants was not related to sedentary time. These associations were stronger in GOLD I–II, lost statistical significance in GOLD III–IV (figure 2, table 2) and became non-significant after adjusting for perceived difficulty with physical activity or neighbourhood crime perception (figure 3, supplementary table S1).

#### Neighbourhood percentages of unemployed and illiterate population

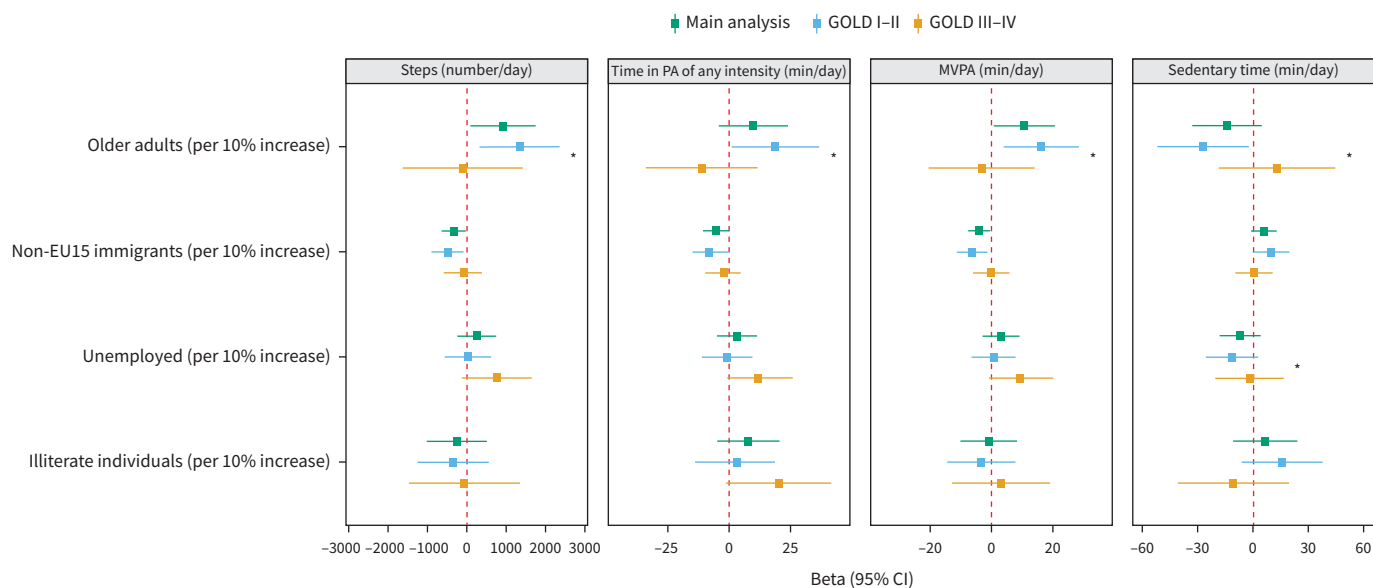
The neighbourhood percentages of unemployed and illiterate population were not associated with any physical activity variable (figure 2, table 2).

#### Sensitivity analyses

Sensitivity analyses excluding extreme values and using mixed models provided results consistent with those of the main analysis (figure 4, supplementary table S2).

#### Discussion

This study explored how neighbourhood characteristics relate to physical activity in people with COPD. Specifically, we found that: 1) higher neighbourhood percentage of older adults was positively associated with steps per day and time spent in MVPA, with stronger effects in GOLD I–II participants, non-significant effects in GOLD III–IV and potentially mediated by perceived difficulty with physical activity; 2) a higher neighbourhood percentage of non-EU15 immigrants was negatively associated with steps per day, time spent in physical activity of any intensity and time spent in MVPA, with a stronger



**FIGURE 2** Adjusted associations between neighbourhood-level sociodemographic and socioeconomic characteristics and objective physical activity in COPD patients in the overall sample and stratified by Global Initiative for Chronic Obstructive Lung Disease (GOLD) severity levels (GOLD I–II and GOLD III–IV). Boxes and error bars indicate the adjusted regression coefficients and 95% confidence intervals (95% CI) per 10% increase in the neighbourhood-level characteristics. Models included all neighbourhood-level characteristics and age, sex, social class, marital status, road traffic noise levels and PM<sub>2.5</sub> as covariates. See all numbers and p-values in table 2. PA: physical activity; MVPA: moderate-to-vigorous physical activity; PM<sub>2.5</sub>: particles with a 50% cut-off aerodynamic diameter of 2.5 µm. \*: p-for-interaction <0.05.

effect in GOLD I–II, not significant in GOLD III–IV, and with both perceived difficulty with physical activity and neighbourhood crime perception acting as potential mediators; and 3) neighbourhood percentages of unemployed and illiterate were not associated with physical activity in COPD. These results were robust to diverse sensitivity analyses.

### Interpretation

Our results showed that a higher neighbourhood percentage of older adults was associated with more steps per day and more time spent in MVPA. Although not statistically significant, similar trends were observed for physical activity of any intensity and sedentary time (in the opposite direction) across all analyses (figure 2). These effects were confined to participants with mild-to-moderate COPD and may have been mediated by perceived difficulty with physical activity, as shown by the secondary analyses. The magnitude of the observed association is substantial: according to European Statistical Office projections, the number of people aged 75–84 years in the European Union is expected to increase by 56% by 2050 [27], potentially leading to an increase of more than twice the minimally important difference [25] in steps per day among people with COPD. Two plausible factors may explain our results. First, since most people with COPD are older adults, having more age-matched neighbours may strengthen social connections that promote physical activity. This is supported by a systematic review highlighting the importance of “social opportunity” (*i.e.*, opportunities for social interaction) in influencing physical activity in older adults [13]. In this regard, having fewer older neighbours has also been reported to weaken social networks [28], reducing physical activity among older adults [29]. Further, strong social connections are linked to lower perceived difficulty with physical activity [30], supporting our interpretation of the secondary analysis that perceived difficulty may act as a mediating factor in the relationship between the percentage of older adults in a neighbourhood and physical activity. Second, people with COPD may imitate the physical activity behaviour of their age-matched neighbours in Catalonia, where 80% of older adults are regularly active [31]. This aligns with BALL *et al.*'s findings [32], who showed that perceiving neighbours as active encourages individuals to engage in active behaviours. Our observation that the proportion of older adults affects physical activity only in people with mild-to-moderate COPD is plausible given that previous research has shown that those with more severe COPD often face physical limitations [33] and stigma [34] that restrict participation in social activities. Additionally, a prior study found that the aesthetics of the built environment were associated with physical activity levels in healthy individuals but not in those with chronic disease [35], further supporting this observation.

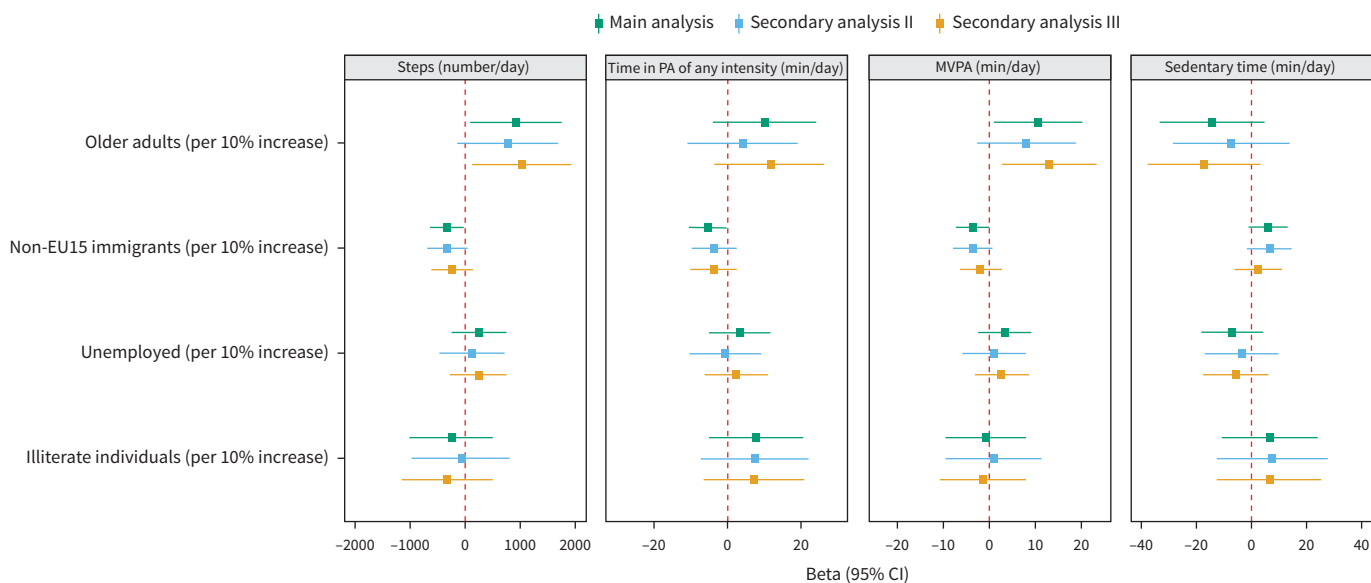
**TABLE 2** Adjusted associations<sup>#</sup> between neighbourhood-level sociodemographic and socioeconomic characteristics and objective physical activity, analysed for the overall sample and stratified by GOLD severity levels, among COPD patients recruited between 2013 and 2015 in Catalonia, Spain

	Main analysis Total sample		Stratified by GOLD severity		p-for- interaction
	Coefficient (95% CI)	p-value	GOLD I-II Coefficient (95% CI)	GOLD III-IV Coefficient (95% CI)	
<b>Patients, n</b>	407		256	151	
<b>Older adults (per 10% increase)</b>					
Steps·day <sup>-1</sup>	922 (84 to 1759)	0.031	1331 (307 to 2355)	-116 (-1638 to 1406)	0.006
Time in PA of any intensity min·day <sup>-1</sup>	10 (-4 to 24)	0.163	19 (1 to 37)	-11 (-34 to 12)	<0.001
MVPA min·day <sup>-1</sup>	11 (1 to 20)	0.035	16 (4 to 28)	-3 (-20 to 14)	<0.001
Sedentary time min·day <sup>-1</sup>	-14 (-33 to 5)	0.148	-27 (-52 to -2)	13 (-19 to 45)	0.002
<b>Non-EU15 immigrants (per 10% increase)</b>					
Steps·day <sup>-1</sup>	-332 (-647 to -16)	0.039	-493 (-908 to -78)	-96 (-596 to 404)	0.459
Time in PA of any intensity min·day <sup>-1</sup>	-5 (-11 to 0)	0.052	-8 (-15 to 0)	-2 (-10 to 5)	0.201
MVPA min·day <sup>-1</sup>	-4 (-7 to 0)	0.050	-6 (-11 to -1)	0 (-6 to 6)	0.366
Sedentary time min·day <sup>-1</sup>	6 (-1 to 13)	0.101	10 (0 to 20)	0 (-10 to 11)	0.195
<b>Unemployed (per 10% increase)</b>					
Steps·day <sup>-1</sup>	250 (-249 to 749)	0.324	29 (-565 to 624)	758 (-132 to 1647)	0.189
Time in PA of any intensity min·day <sup>-1</sup>	3 (-5 to 12)	0.432	-1 (-11 to 10)	12 (-1 to 26)	0.096
MVPA min·day <sup>-1</sup>	3 (-3 to 9)	0.276	1 (-6 to 8)	9 (-1 to 20)	0.088
Sedentary time min·day <sup>-1</sup>	-7 (-18 to 4)	0.230	-11 (-26 to 3)	-2 (-21 to 17)	0.022
<b>Illiterate individuals (per 10% increase)</b>					
Steps·day <sup>-1</sup>	-254 (-1018 to 510)	0.513	-350 (-1259 to 559)	-64 (-1475 to 1347)	0.137
Time in PA of any intensity min·day <sup>-1</sup>	8 (-5 to 21)	0.222	3 (-14 to 19)	20 (-1 to 42)	0.180
MVPA min·day <sup>-1</sup>	-1 (-10 to 8)	0.871	-3 (-14 to 8)	3 (-13 to 19)	0.087
Sedentary time min·day <sup>-1</sup>	7 (-11 to 24)	0.455	16 (-6 to 38)	-10 (-41 to 20)	0.103

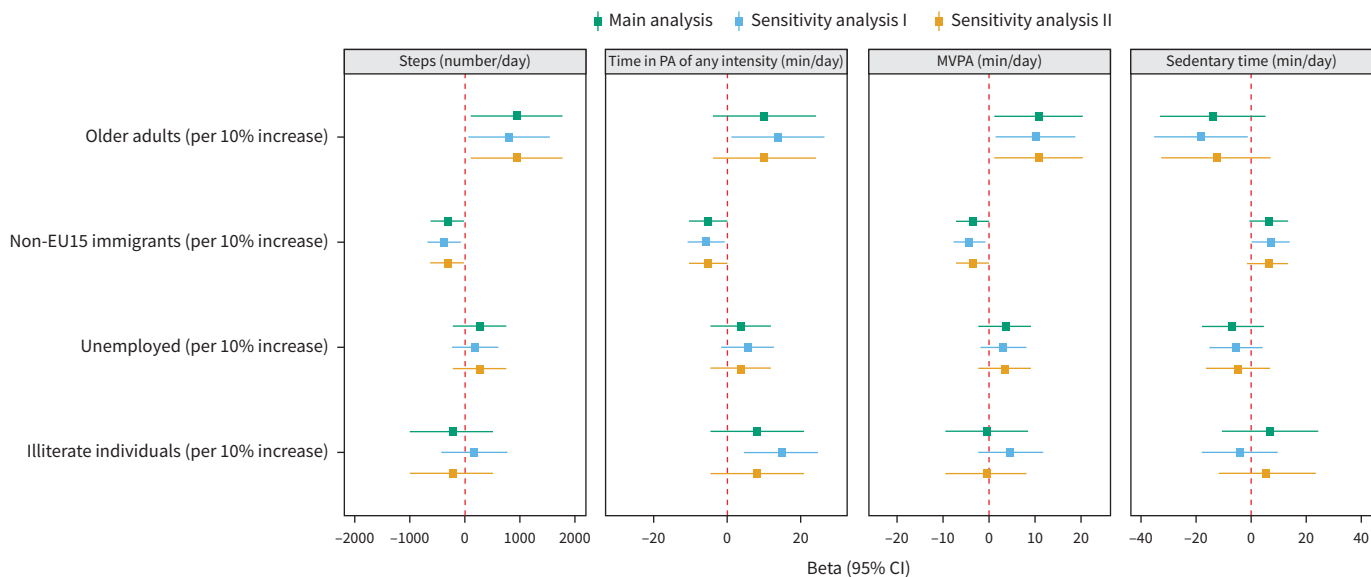
GOLD: Global Initiative for Chronic Obstructive Lung Disease; PA: physical activity; MVPA: moderate-to-vigorous physical activity; PM<sub>2.5</sub>: particles with a 50% cut-off aerodynamic diameter of 2.5 µm. <sup>#</sup>: each physical activity variable is modelled in a single model including all neighbourhood characteristics as exposures and adjusted for age, sex, social class, marital status, road traffic noise levels and PM<sub>2.5</sub>.

Our findings revealed that higher neighbourhood percentages of non-EU15 immigrants were associated with fewer steps per day, less time spent in physical activity of any intensity and less time spent in MVPA. These findings were consistent across secondary and sensitivity analyses. However, after adjusting for neighbourhood crime perception, the associations became non-significant. Our results align with those of OSYPUK *et al.* [10] in the USA, who reported lower physical activity levels among healthy Hispanic adults in immigrant-dense neighbourhoods. The exact mechanisms behind these relationships remain unclear. However, these findings, novel in COPD research, suggest that neighbourhoods with higher immigrant density may reduce physical activity due to lower social cohesion and negative safety perceptions, as indicated by our indirect mediation analysis. This is supported by a qualitative study in a culturally similar sample from Madrid, where participants often viewed immigrants as outsiders, which discouraged them from using public spaces [9]. These findings highlight the perceptions of the local population rather than inherent characteristics of immigrant communities. In diverse neighbourhoods, social cohesion may face challenges, potentially influencing physical activity behaviours. This aligns with evidence showing that stronger social cohesion is positively associated with MVPA in adults aged 40 to 75 years [36], reinforcing the importance of fostering inclusive and connected communities.

Our analyses found no associations between the percentages of unemployed and illiterate residents and any physical activity measure. To our knowledge, no existing literature directly compares or contrasts these findings. It is possible that these factors do not exert any effect on physical activity. It is also likely that the high walkability of Catalan neighbourhoods mitigates any potential negative effects of adverse area-level SES on physical activity. Indeed, previous research has shown high neighbourhood walkability in our recruitment area [37], in agreement with a consistent relation – independent from SES – between high neighbourhood walkability and higher levels of objective and self-reported physical activity in healthy adults from the USA [38] and Western Europe [11, 12].



**FIGURE 3** Adjusted associations between neighbourhood characteristics and objective physical activity in COPD patients in the main analysis and including self-reported difficulty with physical activity and neighbourhood crime perception as additional covariates. Boxes and error bars indicate the adjusted regression coefficients and 95% confidence intervals (95% CI) per 10% increase in the neighbourhood-level characteristics. Models included all neighbourhood-level characteristics and age, sex, social class, marital status, road traffic noise levels and PM<sub>2.5</sub> as covariates. See all numbers and p-values in supplementary table S1. PA: physical activity; MVPA: moderate-to-vigorous physical activity; PM<sub>2.5</sub>: particles with a 50% cut-off aerodynamic diameter of 2.5 µm.



**FIGURE 4** Adjusted associations between neighbourhood characteristics and objective physical activity in COPD patients in the main analysis and sensitivity analyses using mixed models with recruitment centre as a random effect and excluding extreme values in exposure variables. Boxes and error bars indicate the adjusted regression coefficients and 95% confidence intervals (95% CI) per 10% increase in the neighbourhood-level characteristics. Models included all neighbourhood-level characteristics and age, sex, social class, marital status, road traffic noise levels and PM<sub>2.5</sub> as covariates. See all numbers and p-values in supplementary table S2. PA: physical activity; MVPA: moderate-to-vigorous physical activity; PM<sub>2.5</sub>: particles with a 50% cut-off aerodynamic diameter of 2.5 µm.

### Implications

Our findings have important implications. Clinically, healthcare providers can use social prescribing to offer locally tailored recommendations for physical activity to COPD patients, particularly those experiencing social isolation or loneliness [39]. Public health initiatives can support these efforts by promoting programmes like Barcelona's *Activa't als parcs* (Get Active in the Parks) [40], which helps older adults stay active through age-friendly walking groups in the city's green spaces. However, participation among foreigners was low (4%). To improve inclusivity, these programmes should implement strategies that encourage immigrant participation and reduce exclusion. By doing so, they can maximise the benefits of a larger older adult population while strengthening social cohesion in culturally diverse communities. Future research should examine how neighbourhood factors, such as social cohesion and crime perception, shape physical activity in COPD patients, combining longitudinal and qualitative approaches to explore their potential mediating role and gain deeper insight into patients' perceptions, experiences and barriers.

### Strengths and limitations

Our study has several strengths. The use of objective measurements of physical activity, official neighbourhood-level data, validated tools and questionnaires, and standardised tests for people with COPD helped minimise measurement error. The analysis accounted for many potential confounders, limiting biased results. Additionally, including participants with varying COPD severity from five cities with diverse sociodemographic, socioeconomic and geographical profiles enhances the generalisability of our findings to other European Mediterranean settings. However, the study also has limitations. The cross-sectional design prevents us from excluding reverse causality, although no plausible mechanism suggests that physical activity behaviours would influence neighbourhood sociodemographic characteristics. Additionally, residual confounding may affect the estimates, particularly due to unmeasured neighbourhood-level factors like service availability; however, results were adjusted for multiple social, economic and demographic factors at both the area- and individual-level, minimising the possibility of residual confounding by economic factors. Finally, using area-level data from 2011 for participants recruited between 2013 and 2015 might introduce some degree of measurement error in the estimation of neighbourhood characteristics. However, the potential bias produced by such error is likely minimal, as previous research estimated that only 1.5% of older adults in Southern Europe change address [41], and the nondifferential nature of this error with respect to physical activity would bias the association estimates towards the null (*i.e.*, lack of association) [42].

### Conclusion

In conclusion, our study suggests that neighbourhood sociodemographic characteristics are associated with physical activity in clinically stable COPD patients, with higher proportions of older adults associated with increased activity and higher proportions of non-EU15 immigrants linked to reduced activity. These findings underscore the importance of considering the neighbourhood social environment when promoting physical activity among COPD patients.

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