

# The association of chronic obstructive pulmonary disease, disability, engagement in social activities, and mortality among US adults aged 70 years or older, 1994–2006

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**Purpose:** To assess associations among chronic obstructive pulmonary disease (COPD), disability as measured by activities of daily living (ADL) and instrumental ADL (IADL), engagement in social activities, and death among elderly noninstitutionalized US residents.

**Materials and methods:** A nationally representative sample of 9,415 adults who were aged  $\geq 70$  years and responded to the Second Supplement on Aging survey in 1994–1996 and mortality follow-up study through 2006 were assessed. Multiple logistic regression analyses were performed to assess the risk of all-cause mortality in participants with COPD after accounting for age, sex, race/ethnicity, and smoking status.

**Results:** At baseline, approximately 9.6% of study participants reported having COPD. Compared with participants without COPD, those with COPD were significantly more likely ( $P < 0.05$ ) to have difficulty with at least one ADL (44.3% versus [vs] 27.5%) and with at least one IADL (59.9% vs 40.2%), significantly less likely to be engaged in social activities (32.6% vs 26.3%), and significantly more likely to die by 2006 (70.7% vs 60.4%; adjusted risk ratio 1.15,  $P < 0.05$ ). The association between COPD and risk for death was moderately attenuated by disability status.

**Conclusion:** COPD is positively associated with disability and mortality risk among US adults aged  $\geq 70$  years. The significant relationship between COPD and mortality risk was moderately attenuated, but was not completely explained by stages of ADL and IADL limitations and social activities.

**Keywords:** chronic obstructive pulmonary disease, mortality, activities of daily living, instrumental activities of daily living, disability

## Introduction

Chronic lower respiratory diseases have been the third leading cause of death since 2008 in the US.<sup>1,2</sup> The most common chronic lower respiratory disease is chronic obstructive pulmonary disease (COPD), which is characterized by chronic airflow obstruction, and at least 75% of COPD-related deaths in the US have been attributed to smoking.<sup>3,4</sup> However, although the prevalence of current smoking among US adults declined from 24.0% in 2000 to 19.6% in 2010, the COPD death rate did not decline as rapidly as the death rates from heart disease, cancer, or all causes.<sup>5,6</sup> Furthermore, a four-decade secular decline in the overall mortality rate among US adults has been much slower among those with COPD than among those with normal lung function.<sup>7</sup>

A recent report from the Global initiative for chronic Obstructive Lung Disease suggests that COPD progression, which results from dyspnea, fatigue, inactivity,

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deconditioning, and aging, may help explain this relatively static trend in the COPD mortality rate.<sup>8</sup> Because the ability of people with COPD to perform daily activities necessary for independent living declines as their COPD progresses, they are more likely to experience disability,<sup>9,10</sup> and as a result are at greater risk for social restriction and depression.<sup>11–13</sup> Furthermore, those people with exacerbated COPD could be more likely to have comorbidities, and have increased risk for death due to the interrelated effects of disability and mental distress.<sup>14–17</sup>

Reflecting the public health challenges posed by COPD, *Healthy People 2020* has proposed five COPD-related objectives, including one that focuses on reducing activity limitations among adults with COPD.<sup>18</sup> However, a lack of consensus regarding the definition of disability has made it difficult to measure and compare across studies and over time.<sup>19</sup> Two of the most frequently used measures of disability are limitations in activities of daily living (ADL)<sup>20,21</sup> and limitations in instrumental ADL (IADL), which are more complex activities than ADL.<sup>22</sup> Both ADL and IADL limitations were used to measure disability among respondents to the Supplement on Aging (SOA) of the National Health Interview Survey (NHIS) in 1984–1986 and 1994–1996.<sup>23</sup> In addition, research demonstrated that modified disability measures of ADL- and IADL-limitation stages had more specific clinical meanings related to secondary prevention of chronic conditions than did simple counts of ADL or IADL difficulties, and ADL stages were associated with mortality over time.<sup>24–26</sup>

In this study, we assessed the relationships between COPD and disability (measured by stages of ADL and IADL limitations), social activities, and death among noninstitutionalized US adults aged 70 years or older and also whether disability and social activities attenuated the relationship between COPD and death.

## Materials and methods

### Data sources

Baseline data for this study were obtained from the Second SOA (SOA II) in the 1994–1996 NHIS, a national survey of civilian noninstitutionalized US adults who were selected through a multistage sampling process. Participation in SOA II was restricted to NHIS participants aged 70 years or older (information available at <http://www.cdc.gov/nchs/soa/soa2.htm>). To ascertain SOA II participants' survival status as of December 31, 2006, the National Death Index (NDI) database as well as data collected during follow-up interviews conducted in 1997–1998 or 1999–2000 as part of the Second

Longitudinal SOA (LSOA II) was applied. Information about the NDI and LSOA II is available on the Centers for Disease Control and Prevention website.<sup>27</sup> The 1994–1996 NHIS and LSOA II study were approved by the Research Review Board of the National Center for Health Statistics, Centers for Disease Control and Prevention.

SOA II surveyed 9,447 respondents with a mean age of 77.3 (standard error = 0.2) years and an overall response rate of 87.4% (<http://www.cdc.gov/nchs/soa/soa2.htm>). After excluding respondents who either had not been tracked for survival status as of December 31, 2006 or had missing values on selected sociodemographics, COPD status, and social activity at baseline, 9,415 respondents (99.7%) were available for this study.

### Variables

Exposure variables were COPD status, stage of ADL limitation, stage of IADL limitation, and social activity status. Respondents' COPD status was based on their affirmative response to the question: "Did a doctor ever tell you that you had chronic bronchitis or emphysema?"

Respondents' ADL-limitation stage was based on difficulties in performing seven ADL, which were assessed by the questions: "By yourself and without using special equipment, how much difficulty do you have a) bathing/showering; b) dressing; c) eating; d) getting in or out of bed or chair; e) walking; f) getting outside; and g) using the toilet, including getting to the toilet?" Response options ranged from no difficulty (0) to unable to perform (3). Consistent with the International Classification of Functioning, Disability, and Health,<sup>28</sup> an index of five ADL stages (ADL 0, no difficulty; ADL I, mild difficulty; ADL II, moderate difficulty; ADL III, severe difficulty; and ADL IV, complete difficulty) were constructed to reflect respondents' difficulties with ADL.<sup>24,29</sup> In our analyses, we combined stages III and IV to obtain adequate statistical power.

Respondents' IADL-limitation stage was based on difficulties in the ability to perform six IADL, which were assessed through the questions: "By yourself, how much difficulty do you have a) preparing your own meals; b) shopping for groceries and personal items, such as toilet items or medicines; c) managing your money, such as keeping track of expenses or paying bills; d) using the telephone; e) doing heavy housework, like scrubbing floors, or washing windows; f) doing light housework, like doing dishes, straightening up, or light cleaning?" Response options again ranged from no difficulty (0) to unable to perform (3), and five stages of IADL difficulty were based on Stineman et al's definition.<sup>25</sup> As done for the ADL-limitation stage,

we combined stages III and IV to obtain adequate statistical power. The ADL and IADL indices have been widely utilized to address disability status,<sup>24–26,29–31</sup> although they have not been validated so far.

Respondents' social activities were based on their response to the following multiple questions: "During the past 2 weeks, did you a) get together socially with friends or neighbors, b) talk with friends or neighbors on the telephone, c) get together with any relatives, not including those living with you, d) talk with any relatives on the telephone, not including those living with you, e) go to church, temple, or another place of worship for services or other activities, f) go to a show or movie, sports event, club meeting, class, or other group event, and g) go out to eat at a restaurant?" Respondents were given one point for each positive response; possible social activity index scores thus ranged from 0 to 7. We constructed a social activity index in which a score of 6 or 7 was classified as high social activity, 4 or 5 as medium social activity, and 0–3 as low social activity. The SOA II social activity questions were widely utilized in previous studies.<sup>30,31</sup>

The covariates in our analyses were age (70–74, 75–79, or ≥80 years), sex, race (white or nonwhite), and smoking status (current smokers, smoked ≥100 cigarettes in lifetime and current smoking every day or some days; former smokers, smoked ≥100 cigarettes in lifetime but were not smoking now; and those who had never smoked).

## Statistical analyses

Our first step was to assess the weighted distributions of all selected characteristics in the study population, both overall and by COPD status. We then assessed the unadjusted cumulative incidence (deaths per 100 respondents) and incidence rate (deaths per 1,000 person-years) through 2006 for groups defined by each selected characteristic. Using two multiple logistic regression models, an initial model that controlled for the selected covariates and a final model that controlled for all the selected characteristics, we calculated risk ratios (RRs) and 95% confidence intervals (CIs) for the relationships between each selected characteristic and the likelihood of dying from any cause among respondents through the end of 2006. We used multiple logistic regression analyses because of violations of the Cox proportional hazard assumption (Schoenfeld residual). Finally, we used a modified Sobel test tailored for a dichotomous outcome variable to assess whether the relationship between COPD status and risk of dying was attenuated by social activities or the stage of ADL or IADL difficulties.<sup>32,33</sup> The standardized coefficients and the

percentage of the total effect from a single mediator were then calculated using a multiple logistic regression models that controlled for covariates. A significant mediating effect was only confirmed if COPD status was significantly associated with both the mediator and risk of death, and the mediator was significantly associated with risk of death.<sup>34</sup> Furthermore, a partial mediating effect was determined if the relationship between COPD and mortality remained significant when the potential mediator was added into the model, and so was a complete mediating effect if the relationship between COPD and mortality was no longer significant with the mediator in the model.<sup>34</sup> SAS-callable SUDAAN (version 10.0.1; Research Triangle Institute, Research Triangle Park, NC, USA) was used in all analyses to account for the complex sampling design.

## Results

### Characteristics of participants at baseline

Of the 9,415 survey participants in our study, 59.8% were women, 60.5% were aged ≥75 years, 89.9% were white, and 48.0% were former or current smokers, 29.1% had at least one difficulty with functional ADL, 42.1% had at least one difficulty with IADL, and 26.9% had a low level of social activities during the previous 2 weeks. Among baseline study participants, 9.6% (95% CI =8.9–10.3) reported having COPD. COPD prevalence did not differ significantly by sex or age, but was significantly higher among white participants than nonwhite participants (10.0% versus [vs] 5.7%), and among current smokers (18.1%) and former smokers (12.8%) than among those never having smoked (5.8%).

Although there were no differences in sex or age groups by COPD status, respondents with COPD were more likely to be white (Table 1, 94.0% vs 89.4%), a former smoker (50.6% vs 36.7%), a current smoker (18.5% vs 9.0%,  $P<0.001$ ), and have low (0–3) social activities in the previous 2 weeks (32.6% vs 26.3%) than respondents without COPD ( $P<0.05$ ). Participants with COPD were less likely than those without COPD to report no functional ADL difficulties (55.7% vs 72.5%) and no IADL difficulties (40.1% vs 59.8%) ( $P<0.05$ ). Persons with COPD compared to those without had significantly greater percentage of persons at higher ADL and IADL stages ( $P<0.05$ ).

Respondents with COPD were significantly more likely to report having any difficulty with each individual ADL and with most IADL than those without COPD (Figure 1A and B,  $P<0.05$ ). They were also significantly less likely to report engaging in four social activities during the previous 2 weeks: getting together with friends or neighbors, going

**Table 1** Baseline distributions of selected characteristics among survey participants, by COPD<sup>a</sup> status: the Second Supplement on Aging, National Health Interview Survey, 1994–1996

Baseline characteristic	Total		COPD		No COPD	
	n <sup>b</sup>	% (95% CI) <sup>c</sup>	n <sup>b</sup>	% (95% CI) <sup>c</sup>	n <sup>b</sup>	% (95% CI) <sup>c</sup>
Total	9,415		883		8,532	
Sex						
Men	3,736	40.2 (39.3–41.1)	350	39.8 (36.1–43.5)	3,386	40.2 (39.3–41.1)
Women	5,679	59.8 (58.9–60.7)	533	60.2 (56.5–63.9)	5,146	59.8 (58.9–60.7)
Age, years						
70–74	3,651	39.5 (38.3–40.6)	353	39.9 (36.9–42.9)	3,298	39.4 (38.2–40.6)
75–79	2,742	29.2 (28.3–30.1)	275	32.0 (28.7–35.3)	2,467	28.9 (27.9–29.8)
≥80	3,022	31.4 (30.2–32.5)	255	28.1 (25.0–31.1)	2,767	31.7 (30.5–32.9)
Race/ethnicity						
White	8,205	89.9 (88.6–91.1)	814	94.0 (92.4–95.6)	7,391	89.4 (88.1–90.7)
Nonwhite	1,210	10.1 (8.9–11.4)	69	6.0 (4.4–7.6)	1,141	10.6 (9.3–11.9)
Smoking status						
Never smoked	4,886	52.0 (50.7–53.3)	277	30.9 (27.5–34.4)	4,609	54.3 (52.9–55.6)
Former smoker	3,418	38.1 (36.8–39.3)	437	50.6 (46.7–54.4)	2,981	36.7 (35.4–38.0)
Current smoker	923	9.9 (9.2–10.6)	162	18.5 (15.8–21.1)	761	9.0 (8.3–9.7)
Stage of ADL limitations <sup>d</sup>						
0	6,607	70.9 (69.7–72.1)	481	55.7 (52.3–59.2)	6,126	72.5 (71.3–73.8)
I	1,397	14.7 (13.8–15.6)	201	22.5 (19.6–25.5)	1,196	13.9 (13.0–14.8)
II	670	7.1 (6.5–7.7)	88	9.7 (7.7–11.7)	582	6.8 (6.1–7.5)
III or IV	703	7.3 (6.6–8.0)	110	12.0 (9.8–14.3)	593	6.8 (6.1–7.5)
Stage of IADL limitations <sup>e</sup>						
0	5,168	57.9 (56.5–59.4)	332	40.1 (36.4–43.9)	4,836	59.8 (58.3–61.3)
I	1,971	21.8 (20.8–22.8)	255	31.4 (27.8–34.9)	1,716	20.8 (19.8–21.8)
II	1,119	12.3 (11.4–13.2)	161	18.9 (16.1–21.7)	958	11.6 (10.7–12.6)
III or IV	730	7.9 (7.3–8.6)	85	9.6 (7.6–11.6)	645	7.7 (7.0–8.5)
Level of social activity <sup>f</sup>						
Low (0–3)	2,569	26.9 (25.7–28.1)	294	32.6 (29.3–35.8)	2,275	26.3 (25.0–27.6)
Medium (4–5)	3,661	38.5 (37.4–39.7)	350	39.0 (35.7–42.2)	3,311	38.5 (37.3–39.7)
High (6–7)	3,185	34.6 (33.2–35.9)	239	28.5 (25.2–31.7)	2,946	35.2 (33.8–36.6)

**Notes:** <sup>a</sup>Chronic obstructive pulmonary disease (COPD); <sup>b</sup>unweighted sample size; <sup>c</sup>weighted percentage and 95% confidence interval (CI) were derived using sample weights; <sup>d</sup>stages of functional activities of daily living (ADL) limitations were based on participant's response to six questions about his/her difficulty in bathing/showering, dressing, eating, getting in or out of bed or chairs, walking, and using or getting to the toilet; <sup>e</sup>stages of instrumental activities of daily living (IADL) limitations were based on participant's response to six questions about his/her difficulty in preparing meals, shopping, managing money, using the telephone, doing light housework, and doing heavy housework; <sup>f</sup>level of social activity was derived from a social activities index score, which was based on participant's responses to multiple questions about his/her participation in the following activities during the previous 2 weeks – getting together with friends or neighbors; talking on the telephone with friends or neighbors; getting together with relatives; talking on the telephone with relatives; going to church, temple, or other place of worship; going to a show or movie, sports events, club meeting, class, or other group event; or going out to eat at a restaurant.

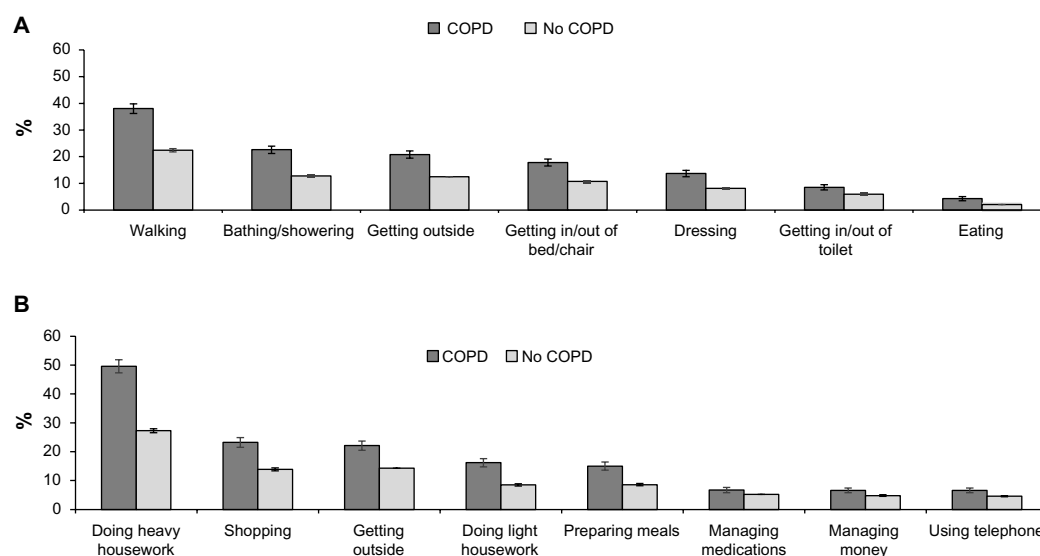
out, eating at a restaurant, going to a place of worship, and going to a group event (Figure 2).

## Cumulative incidence of deaths and incidence of deaths per 1,000 person-years

During follow-up from 1994–1996 through 2006, 5,790 of the original survey participants died (61.4%, 95% CI 60.1–62.6). Results from fully adjusted logistic regression analyses showed that mortality risk was significantly higher among men than among women, significantly higher among those aged 75 years or older than among those aged 70–74 years, and significantly higher among current and former smokers than among those who had never smoked (Table 2,  $P<0.001$ ).

Similar patterns were observed in terms of incidence of deaths per 1,000 person-years.

The mortality risk with adjustment for age, sex, race/ethnicity, and smoking status increased with stage of ADL difficulties ( $P<0.001$ ) and stage of IADL difficulties ( $P<0.001$ ), and declined with level of engagement in multiple social activities ( $P<0.001$ ). Mortality risk was higher among those with baseline COPD than among those without (70.7% vs 60.4%,  $P<0.05$ ; adjusted RR = 1.15, 95% CI 1.09–1.21, Table 2, Model 1). After adjustment for all variables in our multiple logistic regression model, sex, age, smoking status, ADL stages, IADL stages, and level of social activity remained significantly associated with mortality risk (Table 2, Model 2; Figure 3). However, COPD was



**Figure 1** Age-adjusted percentage and 95% confidence intervals of any difficulty of activities of daily living (A) and instrumental activities of daily living (B) among survey respondents aged 70 years or older, by chronic obstructive pulmonary disease (COPD) status: the Second Supplement on Aging, 1994–1996.

associated with higher mortality risk among participants classified as having no difficulty, mild difficulty, or moderate difficulty with ADL ( $P < 0.05$ ), but not among those classified as having severe difficulty or complete difficulty with ADL (Figure 3A). Similarly, COPD was associated with mortality risk only among participants classified as having no difficulty or moderate difficulty with IADL, but not among those classified as having mild, severe, or complete difficulty with IADL (Figure 3B). In contrast, the level of engagement in social activities was positively associated with the risk of COPD-related mortality (data not shown).

## Mediation effects of ADL, IADL, and level of social activities

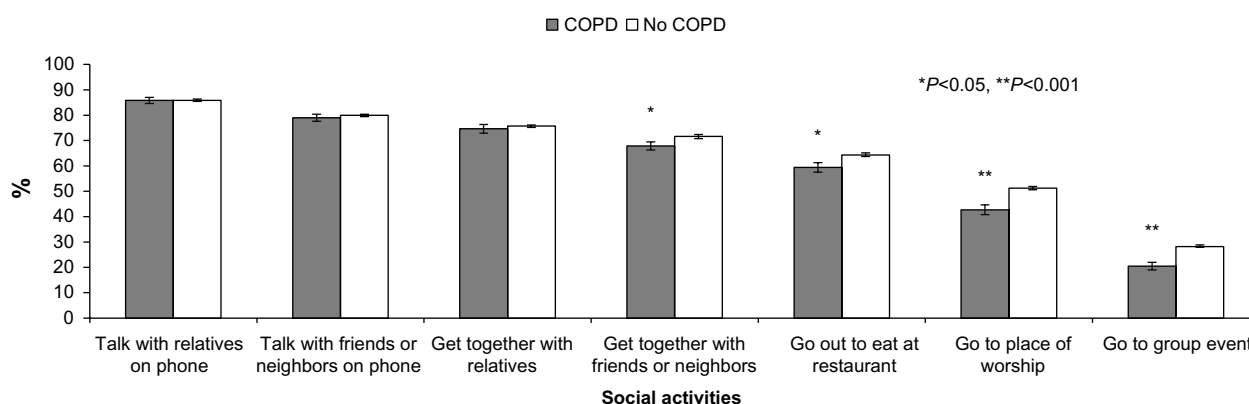
Results from the Sobel test indicated that the relationship between participants' COPD status and their mortality

risk through 2006 was moderately attenuated by their ADL-difficulty stage (indirect effect [IE] = 39.7%) and their IADL difficulty stage (IE = 41.8%), and slightly attenuated by their level of social activity (IE = 11.0%).

## Discussion

Consistent with findings from a study in Finland,<sup>10</sup> our results showed that community-dwelling older adults with COPD were more likely to report having ADL and IADL difficulties and less likely to report participating in social activities than those without COPD. These findings also supported previous study results that COPD reduced the functional capacity of COPD patients and their ability to perform daily activities involving the upper and lower extremities.<sup>35,36</sup>

Our finding that mortality risk was associated with partial ADL difficulty but not with complete ADL difficulty among



**Figure 2** Age-adjusted percentage and 95% confidence intervals of any engagement in selected social activities during the previous 2 weeks among survey respondents aged 70 years or older, by chronic obstructive pulmonary disease (COPD) status: the Second Supplement on Aging, 1994–1996.



**Table 2** Cumulative incidence of deaths and incidence of deaths per 1,000 person-years through December 31, 2006 among 9,415 noninstitutionalized US adults aged  $\geq 70$  years by selected baseline characteristics: the Second Longitudinal Study of Aging, 1994–2006

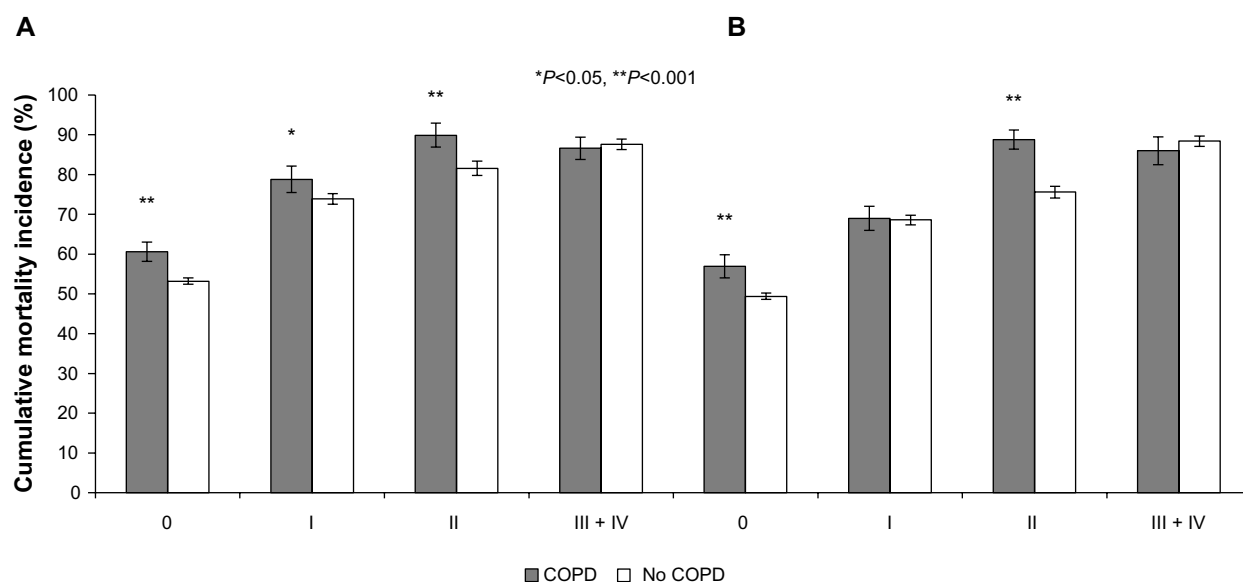
Baseline characteristic	Number of deaths	Cumulative incidence, % (95% CI)	Incidence per 1,000 person-years, % (95% CI)	Model 1 <sup>a</sup> RR (95% CI)	Model 2 <sup>b</sup> RR (95% CI)
Total	5,790	61.4 (60.1–62.6)	76.4 (74.2–78.6)		
Sex					
Men	2,486	65.8 (64.2–67.4)	86.9 (83.4–90.4)	1.14 (1.10–1.18)	1.15 (1.11–1.19)
Women	3,304	58.4 (56.9–59.9)	70.0 (67.5–72.5)	1.0 (referent)	1.0 (referent)
Age, years					
70–74	1,607	44.2 (42.2–46.2)	47.7 (45.0–50.3)	1.0 (referent)	1.0 (referent)
75–79	1,662	60.7 (58.8–62.6)	73.9 (70.4–77.3)	1.42 (1.34–1.49)	1.34 (1.28–1.41)
$\geq 80$	2,521	83.7 (82.4–84.9)	132.7 (128.2–137.2)	1.98 (1.89–2.08)	1.79 (1.71–1.87)
Race/ethnicity					
White	5,026	61.3 (60.0–62.6)	76.2 (73.9–78.5)	1.0 (referent)	1.0 (referent)
Nonwhite	764	62.1 (59.0–65.2)	78.3 (72.4–84.1)	1.03 (0.98–1.08)	0.97 (0.92–1.03)
Smoking status					
Never smoked	2,855	58.2 (56.6–59.8)	69.4 (66.6–72.1)	1.0 (referent)	1.0 (referent)
Former smoker	2,158	62.8 (61.0–64.6)	80.4 (76.9–84.0)	1.11 (1.07–1.15)	1.08 (1.04–1.13)
Current smoker	663	72.0 (68.9–75.0)	100.1 (92.8–107.5)	1.34 (1.28–1.40)	1.29 (1.22–1.36)
Stage of ADL limitations <sup>c</sup>					
0	3,612	53.9 (52.4–55.4)	61.4 (59.1–63.7)	1.0 (referent)	1.0 (referent)
I	1,179	76.1 (73.9–78.2)	102.4 (95.3–109.4)	1.34 (1.29–1.39)	1.20 (1.15–1.25)
II	562	82.7 (79.3–86.1)	129.1 (121.0–137.3)	1.42 (1.35–1.50)	1.22 (1.13–1.32)
III or IV	420	87.4 (84.5–90.3)	175.1 (161.6–188.6)	1.50 (1.43–1.58)	1.20 (1.10–1.30)
Stage of IADL limitations <sup>d</sup>					
0	2,596	49.9 (48.3–51.5)	59.9 (57.7–62.1)	1.0 (referent)	1.0 (referent)
I	1,352	68.6 (66.5–70.8)	85.8 (79.7–91.8)	1.27 (1.22–1.32)	1.14 (1.10–1.19)
II	862	77.5 (74.8–80.1)	129.0 (121.1–136.9)	1.39 (1.33–1.46)	1.21 (1.14–1.28)
III or IV	645	88.1 (85.7–90.6)	196.6 (181.1–212.2)	1.58 (1.50–1.66)	1.36 (1.28–1.46)
Social activity <sup>e</sup>					
Low (0–3)	1,949	75.9 (74.0–77.9)	115.7 (110.3–121.0)	1.36 (1.30–1.43)	1.21 (1.15–1.27)
Medium (4–5)	2,282	62.4 (60.6–64.2)	77.5 (74.2–80.9)	1.17 (1.12–1.22)	1.10 (1.05–1.14)
High (6–7)	1,559	48.9 (46.9–50.9)	53.5 (50.8–56.3)	1.0 (referent)	1.0 (referent)
COPD status <sup>f</sup>					
No	5,159	60.4 (59.1–61.7)	74.1 (71.8–76.4)	1.0 (referent)	1.0 (referent)
Yes	631	70.7 (67.4–74.0)	102.0 (93.4–110.6)	1.15 (1.09–1.21)	1.07 (1.01–1.13)

**Notes:** <sup>a</sup>Model 1 – relative risk (RR) and 95% confidence interval (CI) obtained from multiple logistic regression models, with adjustment for age, sex, race/ethnicity, and smoking status; <sup>b</sup>model 2 – RR and 95% CI obtained from multiple logistic regression models that adjusted for all covariates in the table; <sup>c</sup>stages of functional activities of daily living (ADL) limitations were based on participant's response to six questions about his/her difficulty in bathing/showing, dressing, eating, getting in or out of bed or chairs, walking, and using or getting to the toilet; <sup>d</sup>stages of instrumental activities of daily living (IADL) limitations were based on participant's response to six questions about his/her difficulty in preparing meals, shopping, managing money, using the telephone, doing light housework, and doing heavy housework; <sup>e</sup>level of social activity was derived from a social activities index score, which was based on participant's responses to multiple questions about his/her participation in the following activities during the previous 2 weeks – getting together with friends or neighbors; talking on the telephone with friends or neighbors; getting together with relatives; talking on the telephone with relatives; going to church, temple, or other place of worship; going to a show or movie, sports events, club meeting, class, or other group event; or going out to eat at a restaurant; <sup>f</sup>chronic obstructive pulmonary disease (COPD) based on self-reported diagnosis of chronic bronchitis or emphysema.

community-dwelling older adults was consistent with previous findings that physical activity limitations, including ADL limitations among people with COPD, were positively associated with mortality risk.<sup>15,17,26</sup> However, it was not clear in the present study why the risk of mortality increased gradually at mild or moderate ADL difficulty (stage I and II) relative to no difficulty with ADL, and then reached a plateau at severe or complete ADL difficulty (stage III or IV). It is plausible that the finding might be attributable to the severity of COPD and/or unknown risk factors. The other possible explanation was that those respondents with severe or complete ADL difficulty were more likely to die at 1 and 5 years, so deaths

among this group leveled off at 10 and 12 years.<sup>26</sup> In addition, the relationship between COPD and all-cause mortality was much more modest compared to what has been described in other cohorts.<sup>37,38</sup> This may be explained by the older age of the cohort, self-reported COPD, or lack of information about severity classification in this study.

The finding that the relationship between COPD and mortality risk was moderately attenuated but was not completely explained by stages of ADL and IADL limitations suggested that the assistance provided by caregivers to the older adults with COPD and with relatively severe activity limitations might help improve their health status.



**Figure 3** Cumulative mortality incidence (%) and 95% confidence intervals through December 31, 2006 among the Second Supplement on Aging participants, by chronic obstructive pulmonary disease (COPD) and either stage of activities of daily living limitations (A) or stage of instrumental activities of daily living limitations (B): Second Longitudinal Study on Aging, 1994–2006.

Although we found that respondents with COPD were less likely to report engaging in social activities than those without COPD, nearly two-thirds of all respondents had a low or medium score in social activity. Results from previous studies have shown that people with COPD were more likely to report being lonely and less likely to report engaging in social activities because of ADL or IADL difficulties.<sup>39</sup> Such a negative association between level of social activities and mortality risk was consistent with previous findings that mortality risk could be reduced by increased participation in social activities.<sup>40–42</sup> However, research on social engagement has shown that its relationship with mortality was complex and could impact health through various channels, such as influencing health behavior, improving psychological conditions, and altering physiologic states.<sup>43</sup>

This study is subject to the following limitations, although our findings could be generalizable to the national noninstitutionalized adult population aged 70 years or older. First, self-reported COPD prevalence in the NHIS data may be underestimated and have influenced our results. However, results of a previous study based on data from the Nurses' Health Study (1988–1996), in which 78% of self-reported COPD cases were validated using objective clinical measures, indicated that self-reported surveys could provide reliable estimates for COPD studies.<sup>44</sup> Second, the subjective measure of activity limitations used in this study have not been validated. Results from at least one previous study suggest that objective measures of physical functioning

might be more sensitive in predicting a preclinical disability than subjective measures, such as self-reported difficulties with ADL and IADL.<sup>45</sup> Results from a more recent study, however, indicated that analyses based on subjective measures of difficulties with daily activities and those based on objective measures of such activities had similar power to predict risk for subsequent disability.<sup>46</sup> In addition, results from another recent study suggest that estimates of self-reported ADL limitations were comparable to those based on the BODE index (which is calculated from clinical measurements of body mass index, airflow obstruction, dyspnea, and exercise capacity).<sup>47</sup> Finally, because of the cross-sectional design of SOA II, we could not determine the causal direction of the associations we found between COPD and ADL and IADL limitations.

## Conclusion

COPD is positively associated with disability and mortality risk among US adults aged 70 years or older. These findings support current efforts to develop effective strategies to mitigate the impact of disability among older adults. For example, there are several effective disease-management and physical activity interventions shown to reduce the progression of functional decline among older adults.<sup>19</sup> The challenge will be to expand their reach and determine how to translate such efforts into practice. In addition, our finding that the excess COPD–mortality relationship was moderately attenuated by stages of ADL and IADL limitations suggests that interventions to improve physical

functioning among COPD patients with relatively high levels of activity limitations might reduce their risks related to the progression of COPD.

## Author contributions

Yong Liu and Janet B Croft developed the conceptual model. Yong Liu performed all statistical analyses and wrote the paper under the direction of Janet B Croft. Lynda A Anderson and Anne G Wheaton contributed to interpretation of the data and critical revision of the manuscript for important public health content. Letitia R Presley-Cantrell and Earl S Ford contributed to critical revision of the manuscript. All authors made significant contributions to data generation/analysis, writing or revising of the manuscript, and gave their final approval of the proof to be published.

## Disclosure

The authors report no conflicts of interest in this work. The findings and conclusions in this report are those of the authors, and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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