Title
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Journal
Respiration, 88(4)

ISSN
0025-7931

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Publication Date
2014

DOI
10.1159/000363772

Peer reviewed

Published in final edited form as:
Respiration. 2014 ; 88(4): 329–338. doi:10.1159/000363772.

Disability and Recovery of Independent Function in Obstructive Lung Disease: The Cardiovascular Health Study

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Abstract

Background—Chronic obstructive lung disease frequently leads to disability. Older patients may transition between disability and independence over time.

Objective—To identify factors associated with transitions between disability and independent function in obstructive lung disease.

Methods—We analyzed data for 4,394 participants in the Cardiovascular Health Study who completed pre-bronchodilator spirometry. We calculated the 1-year probability of developing and resolving impairment in ≥1 Instrumental Activity of Daily Living (IADL) or ≥1 Activity of Daily Living (ADL) using transition probability analysis. We identified factors associated with resolving disability using relative risk regression.

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Conflict of Interest

Dr. Avdalovic has received research support from Merck, Glaxo-Smith Kline and Novartis. Dr. Barr has received grants or contracts from NIH, US-EPA, and the Alpha1 Foundation; in-kind contribution from Cenestra Health, travel reimbursement by Boeringher Ingleheim, and royalty from UpToDate. Dr. Fan has received grants from NIH and VA and has served as a consultant to Uptake Medical. Dr. Krishnan has received grants from NIH and PCORI, and royalty from UpToDate. No other authors have any financial interests to report, and none of the authors report any conflicts of interest with the material in this manuscript.

Results—The prevalence of IADL impairment was higher among moderate (23.9%) and severe (36.9%) airflow obstruction compared to normal spirometry (22.5%; p<0.001). Among participants with severe airflow obstruction, 23.5% recovered independence in IADLs and 40.5% recovered independence in ADLs. In adjusted analyses, airflow obstruction predicted development of IADL, but not ADL impairment. Participants with severe airflow obstruction were less likely to resolve IADL impairment (RR 0.67, 95% CI 0.49-0.94). Compared to the most active persons (≥28 blocks walked per week), walking less was associated with decreased likelihood of resolving IADL impairment (7-27 blocks: RR 0.81, 0.69-0.86, and < 7 blocks: RR 0.73, 0.61 -0.86). Increased strength (RR 1.16, 1.05-1.29) was associated with resolving IADL impairment.

Conclusions—Disability is common in older persons, especially those with severe airflow obstruction. Increased physical activity and muscle strength are associated with recovery. Research on interventions to improve these factors among patients with obstructive lung disease and disability is needed.

Keywords

chronic airflow obstruction; activities of daily living; disability

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a progressive disease recognized as a major cause of disability worldwide.[1] Understanding the role of functional limitations and disability in chronic illness is a key priority for research recommended by the Institute of Medicine,[2] and respiratory impairment is an important factor contributing to functional limitations[3-7]. Once persons with obstructive lung disease develop a disability, how likely they are to remain disabled or recover independence over time is not well understood.

To better describe the longitudinal trajectory of function limitation in obstructive lung disease, several studies have examined changes in health status over time. These studies have found that, on average, health-related quality-of-life [8-11] and functional performance[12] worsen over time, and several authors have suggested that the course of COPD is a spiral of decline characterized by progressively worsening physical functioning.[13,14]

Data from other populations suggest, however, that disability is a dynamic condition and that chronically ill patients may often transition between disability and independence over time[15]. Furthermore, patients with a new impairment in activities of daily living (ADL) often recover independent function[16]. In chronic lung disease, a longitudinal Dutch study found that patients with self-reported asthma or COPD had several different disability trajectories, including recovery in function[17].

Disability in obstructive lung disease may therefore be more dynamic than originally thought, and understanding of potentially reversible factors associated with recovery of independent function would enable the development or implementation of programs to improve functional status for patients with obstructive lung disease. Using transition probability analysis, the aims of this study are to estimate the probability of transitioning between disability and no disability over time in a larger cohort of older persons with and without lung disease. We then sought to identify the factors that are associated with development and recovery from disability, and whether they differed between those with and without lung disease.

MATERIAL AND METHODS

Participants

The Cardiovascular Health Study (CHS) is a population-based, longitudinal study of coronary heart disease and stroke.[18] Community-dwelling adults ≥ 65 years were identified through Medicare eligibility lists in four United States communities, and were excluded if they needed a wheelchair, received hospice care, radiation treatment, or chemotherapy. 5201 participants were recruited in 1989–1990 (first cohort) and an additional 687 African American participants in 1992-1993 (second cohort). Socio-demographic and health data were obtained from personal interviews, medical record review, and clinical examination. Subjects participated in yearly study visits which included assessments of disability. Mortality was ascertained by surveillance and semi-annual contact with participants and their families.

Spirometry was performed during 1989–1990 (first cohort only), 1993–1994 (both cohorts), and 1996–1997 (both cohorts). This study used the first year in which spirometry occurred as the index visit. Participants provided informed consent. Institutional review board approval was obtained.

Identification of participants with airflow obstruction

The CHS pulmonary function testing procedures are detailed elsewhere.[19] We included spirometry values meeting the ATS 1994 recommendations (grade A, B, or C), and excluded unreasonably high and low values (FEV_1 >5.5, FEV_1 <0.5, FVC >6.0, or FVC <0.5).[19]

Using reference equations from NHANES III,[20] airflow obstruction was defined as FEV_1/FVC < lower limit of normal (LLN), and severity of obstruction was categorized as *mild* (80% < FEV_1); *moderate* (50% < FEV_1 ≤ 80%); and *severe* (FEV_1 < 50% predicted).

Among those without obstruction, possible restrictive lung disease was defined as having a FVC < LLN. Restriction may be due to several different etiologies including obesity, muscular weakness, and (rarely) interstitial lung disease[21]. However, restrictive lung disease cannot be definitively diagnosed with spirometry alone and requires lung volumes, which were not performed in CHS, to confirm the diagnosis. Many persons with a reduced FVC and FEV_1 but normal ratio have airways disease[22], but over time these patients are as likely to develop obstruction or restriction[23]. Because of the inaccuracy in correctly categorizing patients in the group of possible restriction, we have limited these analyses to those with either normal spirometry or airflow obstruction.

Disability

Disability was assessed with both instrumental activities of daily living (IADL) and activities of daily living (ADL). IADLs were defined as a self-reported difficulty or inability to perform any of the following: heavy housework, light housework, shopping, preparing meals, paying bills, or using the phone. ADLs were defined as difficulty or inability with walking around the home, getting out of bed, eating, dressing, bathing, or using the toilet. Because only very severe airflow obstruction is likely to result in difficulties with ADLs such as using the toilet, bathing or eating, we focused the primary analysis on development and recovery from IADL impairment.

Covariates

We assessed variables potentially associated with development or resolution of disability. We included comorbidities from the Charlson Index[24] available in CHS to construct a comorbidity count (0, 1 or ≥2) from 10 conditions (kidney disease, liver disease, leukemia, lymphoma, cancer, stroke/TIA, claudication, congestive heart failure, myocardial infarction, and diabetes). Self-reported physician diagnosis of asthma was included as a separate variable. A score ≥10 on the 10-item Center for Epidemiologic Studies Short Depression Scale (range 0-30), was considered depressed.[25] A score of <80 on the Modified Mini Mental State Exam (on a 100-point scale) was defined as a cognitive impairment.[26] Hand grip strength (kilograms) was measured using a handheld Jamar Dynamometer. Physical activity was measured as the number of self-reported blocks walked during the previous week. Severity of disability was measured as the total number of self-reported impairments. The ATS-DLD-78 scale was used to measure dyspnea (range 0-5).[27]

We imputed missing values of disability status if the patient was alive by interpolation between two known values where possible. Otherwise the missing value was imputed from the person's last available value, self-rated health, and eventual date of death[28]. Over the 6-year study period, 8% of IADL values were imputed.

Analysis

Transition probabilities—We used transition probability analysis to estimate the transition probabilities between 3 states for each category of lung disease based on the 2 time periods after baseline spirometry was performed.[29] We defined 3 possible states: 1) alive without disability, 2) alive and disabled, and 3) dead (Figure 1).

Predicting 1-year risk of developing and resolving disability—We focused our regression analysis on the transitions between disabled and non-disabled states. We used relative risk regression with generalized linear models using Poisson regression with robust error estimates to estimate the risk of developing or resolving one or more disabilities over the next year[30]. For the analysis, we included all one-year intervals following administration of spirometry, because most participants in the first cohort had spirometry measured on two occasions, those individuals contributed two sets of interval data to the transition probably analysis. We did not use logistic regression because the odds ratio may over-estimate the relative risk in outcomes with >10% probability.

Models were adjusted for baseline factors potentially associated with disability: age, gender, marital status, smoking status, comorbidities, asthma, and strength; as well as factors measured yearly: hospitalization in the last year, severity of disability, depression, cognitive impairment, and blocks walked in the last week. For variables that were collected yearly, the transition analysis included the value of the variable at the start of the 1-year transition interval. We determined whether the factors associated with resolving IADL or ADL impairment differed between participants with and without airflow obstruction with interaction terms to assess for effect modification.

RESULTS

Among 4,861 participants with usable spirometry, we included 1048 with airflow obstruction and 3346 with normal spirometry (Figure 2). Participants with airflow obstruction were more likely to be male ,more likely to have smoked, and more dyspneic than those with normal lung function (Table 1). In addition, compared to participants with normal lung function, those with obstruction were more likely to have cognitive impairment, walked fewer blocks, and had better grip strength.

Prevalence of disability at baseline

IADL impairment was more frequent among obstructive lung function compared to normal lung function (27.2% vs. 22.5%, p<0.001) (Table 2). Difficulty performing heavy housework was more common in obstruction than in normal lung function (p=0.007) and there was no significant differences in other impairments. The prevalence of any baseline IADL disability was higher among those with severe airflow obstruction (36.9%) compared to moderate (23.9%) mild obstruction (23.5%) or normal spirometry (22.5%) (p<0.001). Presence of ADL impairment did not differ between those with airflow obstruction compared to normal lung function (Table 2).

Transition Probabilities

A total of 6,987 1-year transition intervals were examined for this analysis. Of these intervals, 5,410 (77.4%) began no IADL impairment, 6,396 (91.5%) with no ADL impairment, 1,577 (22.6%) had at least one IADL impairment and 591 (8.5%) with at least one ADL impairment. The probability of developing impairment in IADL over 1 year was highest for those with severe obstruction (0.24), and lowest for those with normal lung function (0.15) or mild obstruction (0.13) (Table 3). A large proportion (30%) of participants with mild obstruction resolved their IADL impairment the next year, and even among participants with severe obstruction, 22% resolved their IADL impairment 1 year later.

The probability of developing ADL impairment over 1-year of follow-up varied from 0.06 to 0.09. Among those with ADL impairment 35% to 45% resolved their impairments over the next year, including 35% of those with severe obstruction.

Predictors of developing and resolving disability over 1 year

After adjustment for baseline demographic characteristics and other comorbidities, severe airflow obstruction was associated with development of IADL impairment over 1-year, with a RR 1.44 (1.11-1.87) compared to normal lung function (Table 4). Recent hospitalization also increased risk of developing impaired IADL. Better grip strength and more blocks walked in a week were associated with reduced risk of developing IADL impairment.

In a model to predict resolution of IADL impairment over the following year, participants with severe obstruction were less likely to resolve their disability compared to normal lung function (RR 0.67, 0.49-0.94). Independent of lung function, we found that increasing grip strength (RR 1.16, 95% CI 1.05 to 1.29) was associated with resolving IADL disability. In addition, compared to those whose baseline physical activity was walking ≥ 28 blocks per week, those who walked 7-27 blocks (RR 0.81, 95% CI 0.69 to 0.95) or < 7 blocks (RR 0.73, 0.61 to 0.86) were less likely to resolve IADL impairment (Table 4).

To determine whether the impact of potentially reversible factors such as better grip strength or number of blocks walked on resolving IADL impairment differed between those with airflow obstruction and those with normal spirometry, we assessed for effect modification with an interaction term for obstruction and grip strength (p=0.29) or obstruction and blocks walked (p=0.28); both were non-significant indicating that the effect of both of these factors were similar for those with and without obstructive lung disease. In a sensitivity analysis excluding patients who reported a physician diagnosis of asthma, we found that the models were similar, with the same factors associated with development or resolution of IADL or ADL impairment.

In adjusted models obstructive lung disease was not associated with development of ADL impairment (Table 5), and did not reduce the likelihood of recovering from ADL impairment. Participants who walked less than 7 blocks were less likely to resolve their ADL impairment (RR 0.77, 0.62-0.96) compared to participants who were the most physically active.

DISCUSSION

In this longitudinal study of older persons we found that although participants with moderate to severe obstruction were more likely to have one or more IADL impairments at baseline, 31% of those with moderate obstruction and 22% of participants with severe obstruction recovered independent function 1-year later. While severe obstructive lung disease decreased likelihood of recovery from IADL impairment, participants with increased grip strength or who walked more at baseline were more likely to recover, independent of severity of airflow obstruction.

Our results suggest that the commonly held view that COPD leads to steadily progressive functional decline with worsening quality of life and disability over time may not be true for many patients and that intervening early to prevent disability may reduce IADL impairment. We used transition analysis to examine the probability of transitioning between different states of impairment over 1-year. Most studies that have demonstrated a progressive deterioration in functional status used average measures over time,[8,12] which does not account for different patterns of disability that may occur.

Only one study that we are aware of has looked at patterns of disability in lung disease.[17] In that study, lung disease (self-reported asthma or COPD) was associated with 7 different trajectories of disability including “mild, but decreasing disability” and “moderately disabled partial regain in functioning after loss”. Our results build on that study, as we were able to better define presence and severity of airflow obstruction using spirometry in a population-based longitudinal cohort. In addition, our findings are consistent with prior research in the older general population suggesting that disability is episodic, and that older patients frequently transition between states of disability and independence.[15]

Although patients with severe obstruction were less likely to recover independent IADL function we found that decreased number of blocks walked and muscle strength predicted recovery from IADL impairment regardless of severity of lung disease. Muscle strength and physical function have been shown to be predictive of development of disability in COPD[31]. In addition, worsening muscle strength and decreased exercise capacity over time are also predictive of new onset of disability measured with the Valued Life Activities scale[32]. Furthermore, decreased physical activity, measured by self-report[33] or with accelerometry[34], is associated with increased risk of COPD exacerbations and COPD hospitalizations.

Although decreased physical activity predicts development of disability, we have also found that increased muscle strength measured with grip strength, and increased physical activity is associated with resolution of IADL impairment, regardless of the severity of obstruction. These findings are consistent with a study by Estaban et al that found that improved physical activity over a 5-year period was associated with improved health-related quality of life in COPD[35]. These results are also in accordance with a study in older patients with a new disability that showed that habitual physical activity shortened recovery and improved maintenance of independence.[16] Our findings suggest that many patients with chronic obstruction may in fact improve, and the factors predicting resolution of impairment in functioning are similar to older adults without lung disease. Of note, all of the participants in our study were able to walk at baseline and were therefore likely able to participate in some physical activity.

Maintenance of physical activity with exercise programs has been shown in randomized trials to slow or prevent functional decline in older persons.[36,37] Pulmonary rehabilitation improves quality of life in COPD and exercise tolerance[38] and may increase the level of physical activity at home as assessed by activity monitors.[39] Additionally bronchodilator therapy[40] and supplemental oxygen[41] may increase exercise tolerance in COPD. Therefore optimization of medical therapy and increased access to pulmonary rehabilitation may be ways to improve physical activity and decrease disability that should be examined in future studies of interventions to promote physical activity in obstructive lung disease. We also found that increased grip strength was associated with recovery of independence among persons with obstructive lung disease and disability. Skeletal muscle dysfunction may also contribute to exercise limitation in COPD, and may affect both upper and lower limb skeletal muscle strength[42]. Progressive resistance exercise is often a component of pulmonary rehabilitation, and can increase both arm and leg muscle strength for patients with COPD.[43] Whether improvement in muscle strength can improve longer term outcomes and reduce disability is not known.

In this older population-based cohort, obstructive lung disease was not associated with development of ADL impairment over 1-year compared to those without lung disease, and did not reduce the likelihood of recovery from ADL impairment. The prevalence of ADL impairment in our study (7%) was lower than the prevalence found in a recent cross-sectional survey study in which 22% of older persons with self-reported COPD (age 60-79) had ADL impairment[44]. Our study differed because all patients were ambulatory at baseline, we were able to confirm the diagnosis of airflow obstruction with spirometry, and we were able to examine whether obstruction predicted development or resolution of impairment over 1-year.

The reason airflow obstruction is associated with impairment in IADLs, but not ADLs, may be because IADL impairment such as heavy housework is more likely to be affected by lung disease than ADLs. For example, ADL impairment such as difficulty eating, getting out of bed or walking around the house reflects much more severe impairment, so that even severe obstruction in most cases may not result in this degree of impairment and where other chronic conditions such as dementia may play a more important role.

Several limitations should be considered. The participants in this study did not receive post-bronchodilator spirometry, and we may therefore have included persons with poorly controlled asthma. However, excluding participants who reported a physician diagnosis of asthma did not change the results of the analysis to predict development or resolution of disability. In addition, although we controlled for chronic illnesses that may contribute to disability, diagnoses such as vision or hearing impairment were not measured in CHS and may have also contributed to IADL or ADL impairment. The CHS only included participants ≥65 years, thus limiting the generalizability of the results. We were unable to assess how many subjects in CHS were participating in pulmonary rehabilitation program. However, pulmonary rehabilitation use among eligible patients is generally low[45]. Furthermore, at the time this study was conducted, pulmonary rehabilitation was not yet covered by Medicare[46]. We imputed a small proportion of missing values for yearly IADL, depression, prior hospitalization within the last year, cognitive status, and blocks walked which may have affected our results.

Conclusions

In conclusion, older persons with obstructive lung disease often experience periods of disability, but often transition from disability to independent functioning. This suggests that for many patients with obstructive lung disease, disability is not steadily progressive, but episodic. Regardless of presence or absence of airflow obstruction, those who remain physically active and have increased muscle strength are more likely to recover from IADL impairment over a 1-year period. Pulmonary rehabilitation may be an approach to improve exercise tolerance and muscle strength among persons with airflow obstruction. Future research is needed to determine whether interventions to increase physical activity and muscle strength in persons with IADL impairment can help patients recover independent function.

Acknowledgments

Funders

Cardiovascular Health Study:

The research reported in this article was supported by contracts HHSN268201200036C, N01-HC-85239, N01-HC-85079 through N01-HC-85086, N01-HC-35129, N01 HC-15103, N01 HC-55222, N01-HC-75150, N01-HC-45133, and grant HL080295 from the National Heart, Lung, and Blood Institute (NHLBI), with additional contribution from the National Institute of Neurological Disorders and Stroke (NINDS). Additional support was provided through AG-023629, AG-15928, AG-20098, and AG-027058 from the National Institute on Aging (NIA). A full list of principal CHS investigators and institutions can be found at http://www.chsnhlbi.org/pi.htm.

Department of Veterans Affairs:

The views expressed in this article are those of the authors and do not necessarily reflect the position or policy of the Department of Veterans Affairs or the United States Government. This material is the result of work supported by resources from the VA Puget Sound Health Care System, Seattle, Washington.

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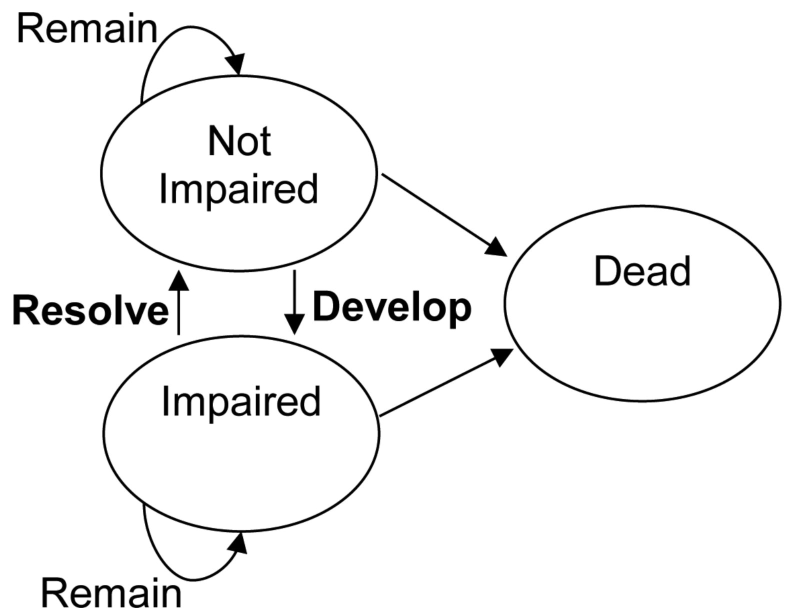

Figure 1.
Transition probability model with states of impairment

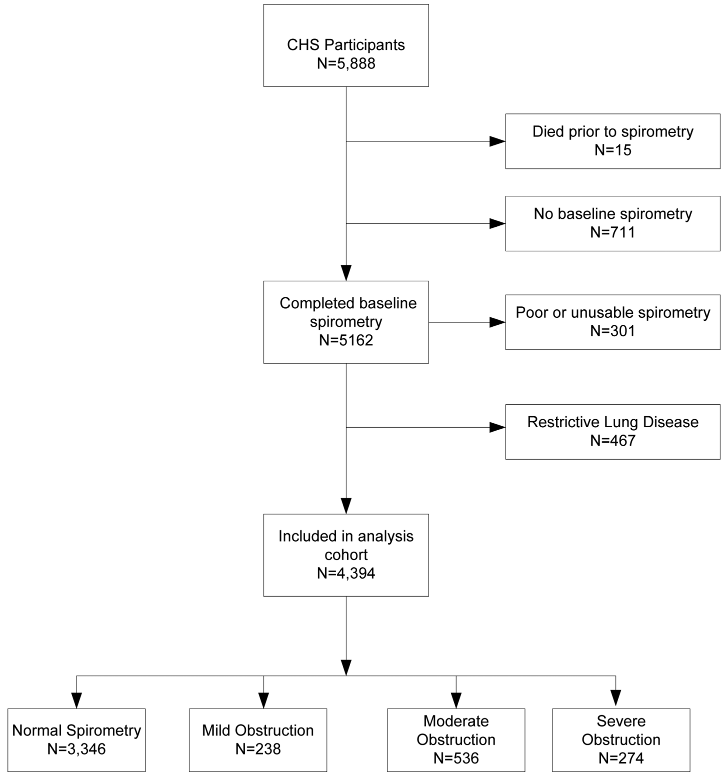

Figure 2.
Participants included in the analysis cohort

Table 1

Baseline characteristics of participants

Characteristic	Normal Lung Function N=3,346	Obstructed N=1,048	p-value
Age years, mean (SD)	72.7 (5.5)	72.7 (5.4)	0.786
Male gender, %	38.9	50.1	<0.001
Race, %			0.552
White	88.1	87.5	
African American	11.9	12.6	
Education, %			<0.001
≤ 8th grade	12.8	16.9	
9-11th grade	12.7	15.5	
12th grade	28.2	27.0	
>12th grade	46.4	40.6	
Married, %	67.9	65.8	0.218
Smoking status, %			<0.001
Never	52.9	22.9	
Past	40.1	53.3	
Current	7.0	23.9	
Body mass index (kg/m^2), %			<0.001
≤25.0	37.4	46.8	
25.0-29.9	43.9	37.5	
≥ 30.0	18.6	15.7	
ATS Dyspnea Scale[a], %			<0.001
0	67.7	48.8	
1	19.3	25.1	
2	4.1	7.8	
3	2.7	5.8	
4	4.0	7.8	
5	2.3	4.6	
Asthma, %	3.7	13.8	<0.001
Depression, %	12.1	13.2	0.321
Chronic Conditions[b], %			0.001
0	71.6	65.8	
1	21.5	24.6	
≥2	6.9	9.5	
Hand grip strength (kg)[c], %			0.003
<20	18.9	15.3	
20-39	64.7	64.5	
≥40	16.4	20.2	
Cognitive Impairment[c], %	7.8	10.2	0.016

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Characteristic	Normal Lung Function N=3,346	Obstructed N=1,048	p-value
Blocks walked in a week, %			
<7	24.7	29.9	0.001
7-27	34.9	35.4	
≥28	40.4	34.7	
Hospitalized in last year, %	8.7	9.1	0.713
FEV_1, liters, mean (SD)	2.27 (0.59)	1.57 (0.59)	<0.001
FEV_1 % Predicted, mean (SD)	97.9 (14.5)	64.7 (20.4)	<0.001
FVC, liters, mean (SD)	3.08 (0.82)	2.81 (0.89)	<0.001
FVC % Predicted, mean (SD)	98.7 (13.4)	85.6 (21.8)	<0.001
FEV_1/FVC ratio, mean (SD)	0.74 (0.05)	0.55 (0.09)	<0.001

Note: Percentages may not sum to 100 due to rounding.

[a] 0=No shortness of breath; 1= troubled by shortness of breath when hurrying or walking up a slight hill; 2=walk slower than people your age; 3=have to stop walking at own pace, 4= have to stop after walking 100 yards; 5=too breathless to leave the house or breathless on dressing or undressing

[b] Other chronic conditions includes myocardial infarction, congestive heart failure, claudication, stroke and/or transient ischemic attack, diabetes, kidney disease, liver disease, lymphoma, leukemia, cancer.

[c] >5% missing information

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Table 2

Baseline prevalence of Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL) impairment

	Normal Lung Function N=3,346		Obstructed N=1,048		p-value
	N	%	N	%	
≥1 ADL Impairment	232	(6.9)	79	(7.5)	0.505
Difficulty performing individual ADLs[a]					
Walking around the home	89	(2.7)	28	(2.7)	0.953
Getting out of bed	158	(4.8)	48	(4.7)	0.890
Eating	11	(0.3)	3	(0.5)	0.830
Dressing	25	(0.8)	9	(0.9)	0.721
Bathing	42	(1.3)	20	(1.9)	0.119
Using the toilet	10	(0.3)	7	(0.7)	0.093
≥1 IADL impairment	754	(22.5)	285	(27.2)	0.002
Difficulty performing individual IADLs[a]					
Heavy Housework	694	(21.2)	259	(25.2)	0.007
Light Housework	53	(1.6)	24	(2.3)	0.131
Shopping	131	(3.9)	46	(4.4)	0.492
Preparing meals	46	(1.4)	20	(1.9)	0.214
Paying bills	26	(0.8)	8	(0.8)	0.967
Using the phone	51	(1.5)	24	(2.3)	0.095

[a]Due to report of multiple impairments within individuals, the prevalence of the individual impairments do not sum to the overall prevalence.

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Table 3

Probability of transitioning between states of impairment in ADLs and IADLs by baseline lung function

Type of disability	Initial state	1-year transition	Normal Lung Function Prob *(95%CI)*	Mild Obstruction Prob *(95%CI)*	Moderate Obstruction Prob *(95%CI)*	Severe Obstruction Prob *(95%CI)*
ADL	**No ADL impairments**	**Develop**	0.09 *(0.06-0.11)*	0.06 *(0.03-0.08*	0.09 *(0.07-0.11)*	0.09 *(0.06-0.12)*
		Remain not impaired	0.90 *(0.87-0.93)*	0.91 *(0.88-0.94)*	0.89 *(0.87-0.92)*	0.89 *(0.86-0.92)*
		Died	0.01 (0.00-0.02)	0.04 *(0.02-0.05)*	0.02 *(0.01-0.04)*	0.02 *(0.01-0.03)*
	≥1 ADL Impairments	**Resolve**	0.42 *(0.27-0.57)*	0.43 *0.28-0.58)*	0.45 *(0.34-0.57)*	0.35 *(0.21-0.49)*
		Remain impaired	0.55 *(0.40-0.70)*	0.55 *(0.40-0.70)*	0.53 *(0.42-0.65)*	0.51 *(0.36-0.66)*
		Died	0.03 *(−0.20-0.08)*	0.02 *(−0.02-0.07)*	0.01 *(−0.01-0.04)*	0.14 *(0.04-0.08)*
IADL	**No IADL impairments**	**Develop**	0.15 *(0.14-0.16)*	0.13 *(0.09-0.16)*	0.19 *(0.16-0.22)*	0.24 *(0.19-0.30)*
		Remain not impaired	0.84 *(0.83-0.85)*	0.84 *(0.80-0.89)*	0.79 *(0.0.76-0.82)*	0.74 *(0.68-0.79)*
		Died	0.01 *(0.01-0.01)*	0.03 *(0.01-0.05)*	0.01 *(0.01-0.02)*	0.02 *(0.00-0.04)*
	≥1 IADL Impairments	**Resolve**	0.36 *(0.33-0.39)*	0.30 *(0.20-0.0.40)*	0.31 *(0.25-0.37)*	0.22 *(0.16-0.29)*
		Remain impaired	0.62 *(0.59-0.64)*	0.65 *(0.55-0.76)*	0.67 *(0.61-0.73)*	0.73 *(0.66-0.80)*
		Died	0.02 *(0.02-0.03)*	0.05 *(0.00-0.10)*	0.02 *(0.00-0.03)*	0.05 *(0.02-0.09)*

Table 4

Relative risk regression to predict developing and resolving IADL impairment over one-year

	Developing ≥1 IADL impairment		Resolving ≥1 IADL impairment	
	Relative Risk	**(95% CI)**	**Relative Risk**	**(95% CI)**
Age	**1.05**	**(1.03-1.06)**	0.99	(0.98-1.00)
Male gender	0.98	(0.80-1.21)	0.97	(0.77-1.20)
Unmarried	1.12	(0.97-1.29)	1.03	(0.89-1.20)
Smoking status				
Never	Ref.	--	Ref.	--
Previous	1.18	(1.02-1.37)	0.94	(0.81-1.09)
Current	1.10	(0.87-1.39)	1.16	(0.91-1.48)
Depression	**1.51**	**(1.27-1.79)**	0.83	(0.69-1.00)
Comorbidity				
0	Ref.	--	Ref.	--
1	**1.40**	**(1.21-1.63)**	0.87	(0.74-1.02)
≥2	**1.82**	**(1.50-2.22)**	**0.57**	**(0.43-0.75)**
Asthma	1.29	(0.99-1.66)	0.86	(0.61-1.21)
Cognitive impairment	1.04	(0.83-1.30)	0.89	(0.59-1.32)
Grip strength, per 10 unit increase[a]	**0.82**	**(0.74-0.91)**	**1.16**	**(1.05-1.29)**
Blocks walked				
<7	**1.66**	**(1.41-1.95)**	**0.73**	**(0.61-0.86)**
7-27	**1.35**	**(1.16-1.57)**	**0.81**	**(0.69-0.95)**
≥28	Ref.	--	Ref.	--
Hospitalized in last year	**1.25**	**(1.03-1.53)**	0.92	(0.74-1.14)
Severity of IADL impairment[b]	NA	--	**0.64**	**(0.53-0.78)**
Lung function				
Normal	Ref.	--	Ref.	--
Mild obstruction	0.86	(0.64-1.15)	0.97	(0.68-1.36)
Moderate obstruction	1.18	(0.98-1.42)	0.97	(0.79-1.21)
Severe obstruction	**1.44**	**(1.11-1.87)**	**0.67**	**(0.49-0.94)**

[a] For example, comparing a participant with a measured grip strength of 50kg to an individual with a measured grip strength of 60kg.

[b] Severity of impairment refers to the total number of impairments reported during the preceding year

Table 5

Relative risk regression to predict developing and resolving ADL impairment over one-year

	Developing ≥1 ADL impairment		Resolving ≥1 ADL impairment	
	Relative Risk	**(95% CI)**	**Relative Risk**	**(95% CI)**
Age	**1.05**	**(1.03-1.06)**	**0.97**	**(0.95-0.99)**
Male gender	1.10	(0.85-1.41)	1.17	(0.89-1.53)
Unmarried	1.18	(0.97-1.43)	1.23	(1.01-1.50)
Smoking status				
Never	Ref.	--	Ref.	--
Previous	1.06	(0.88-1.30)	1.00	(0.82-1.22)
Current	1.06	(0.79-1.43)	0.84	(0.58-1.22)
Depression	**1.85**	**(1.52-2.25)**	**0.70**	**(0.55-0.89)**
Comorbidity				
0	Ref.	--	Ref.	--
1	**1.61**	**(1.32-1.96)**	0.89	(0.71-1.12)
≥2	**1.87**	**(1.46-2.41)**	0.87	(0.64-1.19)
Asthma	1.16	(0.83-1.63)	0.75	(0.49-1.15)
Cognitive impairment	1.11	(0.85-1.45)	0.82	(0.52-1.31)
Grip strength, per 10 unit increase[a]	**0.83**	**(0.74-0.94)**	1.00	(0.88-1.14)
Blocks walked[b]				
<7	**2.14**	**(1.72-2.66)**	**0.77**	**(0.62-0.96)**
7-27	**1.37**	**(1.10-1.70)**	0.87	(0.69-1.09)
≥28	Ref.	--	Ref.	--
Hospitalized in last year	**1.55**	**(1.23-1.95)**	1.03	(0.77-1.40)
Severity of ADL impairment[b]	NA	--	0.91	(0.82-1.02)
Lung function				
Normal	Ref.	--	Ref.	--
Mild obstruction	0.71	(0.46-1.09)	1.26	(0.89-1.77)
Moderate obstruction	0.90	(0.70-1.15)	1.17	(0.89-1.52)
Severe obstruction	0.94	(0.63-1.38)	0.93	(0.59-1.47)

[a] For example, comparing a participant with a measured grip strength of 50kg to an individual with a measured grip strength of 60kg.

[b] Severity of impairment refers to the total number of impairments reported during the preceding year