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Quality of life in relation to upper and lower respiratory conditions among retired 9/11-exposed firefighters with pulmonary disability

Amy Berninger · Mayris P. Webber · Jessica Weakley · Jackson Gustave · Rachel Zeig-Owens · Roy Lee · Fairouz Al-Othman · Hillel W. Cohen · Kerry Kelly · David J. Prezant

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Abstract
Purpose To examine health-related quality of life (HRQoL) and World Trade Center (WTC) cough syndrome conditions in male firefighters who retired due to a 9/11-related pulmonary disability.
Methods From 3/1/2008 to 1/31/2009, we contacted 275 disability-retired firefighters and compared their HRQoL and current aerodigestive conditions to those from WTC-exposed non-disabled retired and active firefighters. Relationships between HRQoL and explanatory variable(s) were examined using multivariable linear regression models.
Results Mean physical component summary (PCS) scores were lowest in disabled retirees compared with non-disabled retirees and actives: 36.4 (9.6), 49.4 (8.7), and 53.1 (5.1), respectively ($P < 0.0001$). Mean mental component summary (MCS) scores were closer: 44.5 (11.9), 48.1 (8.5), and 48.7 (7.4), respectively ($P < 0.0001$). In multivariable models, after adjustment for many factors, PCS scores were not associated with early WTC arrival, but were inversely associated with disability retirement and all WTC cough syndrome conditions. MCS scores were inversely associated with early WTC arrival and most WTC cough syndrome conditions, but were not associated with disability retirement.
Conclusion WTC cough syndrome conditions predict lower HRQoL scores even 8 years after exposure, independent of retirement status. These data suggest that monitoring physical conditions of individuals with occupational exposures might help identify those at risk for impaired HRQoL.

Keywords World Trade Center · Respiratory health · Occupational medicine · Firefighters · Quality of life · Disability retirement

A. Berninger · J. Weakley · R. Zeig-Owens · F. Al-Othman
Department of Medicine, Montefiore Medical Center, Bronx, NY, USA
e-mail: amy.berninger@gmail.com

J. Weakley
e-mail: weaklej@fdny.nyc.gov

R. Zeig-Owens
e-mail: rachel@fdny.nyc.gov

F. Al-Othman
e-mail: falothma@montefiore.org

A. Berninger · M. P. Webber (✉) · J. Weakley · J. Gustave · R. Zeig-Owens · R. Lee · K. Kelly · D. J. Prezant
Fire Department of the City of New York, Bureau of Health Services, 9 Metrotech Center, Brooklyn, NY 11201, USA
e-mail: webberm@fdny.nyc.gov

J. Gustave
e-mail: gustavj@fdny.nyc.gov

R. Lee
e-mail: leero@fdny.nyc.gov

K. Kelly
e-mail: Kellykj@fdny.nyc.gov

M. P. Webber · H. W. Cohen
Department of Epidemiology and Population Health, Albert Einstein College of Medicine, Bronx, NY, USA
e-mail: hillel.cohen@einstein.yu.edu

D. J. Prezant
Department of Medicine, Montefiore Medical Center and Albert Einstein College of Medicine, Bronx, NY, USA
e-mail: prezand@fdny.nyc.gov

Abbreviations

9/11	September 11, 2001
WTC	World Trade Center
FDNY	Fire Department, City of New York
EMS	Emergency medical service
GERD	Gastroesophageal reflux disease
FEV_1	Forced expiratory volume in 1 second
COPD	Chronic obstructive pulmonary disease
HRQoL	Health-related quality of life
IRB	Institutional Review Board
SF-12v2	Short Form Health Survey-12, version 2
PCS	Physical composite summary
MCS	Mental composite summary
NHLBI	National Heart, Lung, and Blood Institute
BMI	Body mass index
FDNY-WTC-MMP	FDNY World Trade Center Medical Monitoring and Treatment Program

Introduction

On September 11, 2001 (9/11), the collapse of the World Trade Center (WTC) released large amounts of particulate dust, smoke, and other pollutants [1–3] into the environment. The Fire Department of the City of New York (FDNY) operated a continuous rescue and recovery effort at the site which lasted until July 25, 2002 [4, 5] and involved over 14,000 firefighters and emergency medical service (EMS) workers. In the first 6 months after 9/11, the FDNY Bureau of Health Services (BHS) identified "World Trade Center Cough Syndrome", defined as a persistent cough that developed after exposure to the site, usually combined with aerodigestive symptoms severe enough to require medical leave for at least 4 weeks [4]. These aerodigestive problems included cough, wheezing, dyspnea, nasal congestion/drip, gastroesophageal reflux disease (GERD) symptoms, bronchodilator response and bronchial hyperreactivity. We further demonstrated that WTC cough syndrome was associated with the severity of initial WTC exposure in a dose–response fashion [4]. Thereafter, in a study involving 12,079 FDNY rescue workers, we reported that pulmonary function, as measured by forced expiratory volume in 1 second (FEV_1), decreased during the first year after 9/11 by an average of 372 ml, which was 12 times the pre-WTC annual decline rate, and which persisted without significant recovery for the length of the study (9/10/2008) [6]. Similar relationships between WTC site exposures and the WTC cough syndrome and its component illnesses—WTC chronic cough, asthma, chronic rhinosinusitis and GERD have also been demonstrated in other groups of rescue/recovery/cleanup workers, volunteers, nearby office workers and residents [7–9].

The relationship between respiratory problems such as asthma, chronic obstructive pulmonary disease (COPD) and chronic cough, and poor general and health-related quality of life (HRQoL) has been well documented in other populations [10–16]. Among those whose respiratory or other problems resulted from work-related exposures, HRQoL may additionally be compromised by early retirement, and subsequent loss of income and disruption of normal social functioning [16–19]. At FDNY, in the 5 years after 9/11, the number of pulmonary disability retirements averaged 146 per year as compared with an average of 49 per year in the 5 years pre-WTC, a nearly threefold increase despite maintaining a similar sized workforce over time.

To date, no studies have examined the impact of persistent and severe post-9/11 respiratory illness in relation to HRQoL among WTC-exposed populations. The goal of the current study was to assess the quality of life in FDNY firefighters who retired due to a 9/11-related pulmonary disability in relation to risk factors, including initial and prolonged WTC site exposures in comparison with WTC-exposed firefighters who retired without a disability and to WTC-exposed firefighters who remained on duty ("active"). We also examined the component conditions of WTC cough syndrome (chronic cough, asthma, chronic rhinosinusitis and GERD) to estimate the association of these factors with HRQoL.

Methods

Disability pension records identified male firefighters who retired from FDNY due to a pulmonary disability between 09/11/01 and 09/10/05 and who worked for at least 1 day at any of the WTC sites ($n = 590$). Recently retired firefighters (i.e., those retired after 9/10/2005) were excluded to limit potential bias from acute adjustment reactions that might have occurred shortly after retirement [20, 21]. FDNY medical directors sent a letter to these 590 firefighters describing the study and requesting their participation in a telephone interview. The letters informed retirees that their answers would not affect their pension status or health insurance. Trained interviewers made up to five attempts to contact each person by telephone. Before beginning the telephone interview, oral consent was obtained using a script approved by the Institutional Review Board (IRB) of Montefiore Medical Center, Bronx, New York.

Telephone questionnaire

Telephone questionnaires were administered between March 1, 2008 and January 31, 2009. Question content was

designed to assess physical and mental HRQoL, and current symptoms (in the last 4 weeks) of WTC cough syndrome conditions, medication use and self perception of asthma control. Questions were adapted from those used in routine screening exams at the Bureau of Health Services (BHS) of FDNY.

Mail questionnaire

Some retirees preferred to answer a paper-and-pencil version of the questionnaire due to hearing problems or for other unspecified reasons. We obtained separate IRB approval for the print version of the questionnaire which was mailed, starting in mid-September 2008, to those who had not yet participated in a telephone interview ($n = 377$). The mailed package consisted of the questionnaire, a consent form as the first page, a letter encouraging participation, and a stamped, self-addressed return envelope. The content of the mail questionnaire was identical to that of the telephone questionnaire. After 2 weeks, those who had not returned the questionnaire were sent a reminder postcard. If there was no return after 2 weeks, another package was sent followed by an additional reminder postcard 2 weeks later. If there was no response after two questionnaires and two postcard mailings, the person was considered a non-participant and was not contacted again.

Comparison groups

In 10/2001, the FDNY BHS expanded its routine medical examinations, scheduled every 12–18 months, to include self-administered physical and mental health questionnaires. In 2008, SF-12 v2 questions were added to these surveys. We used two comparison groups of WTC-exposed firefighters, non-disabled retirees ($n = 938$) and actives ($n = 3{,}465$). Inclusion criteria for the comparison groups were based on the age range (within 1 year) and survey completion (within 6 months) of the disabled group. Non-disabled retirees for the comparison group were required to have retired before 9/10/2005 to avoid possible adjustment reactions to retirement, a similar requirement to that imposed on the disabled group.

Measures

Quality of life

HRQoL was assessed using the Short Form 12-item, version 2 (SF-12v2) [22], which was the first section of our questionnaire. The SF-12v2 is a well-validated quality-of-life questionnaire relating to health and consists of 12 items covering 8 dimensions: physical function, role physical, bodily pain, general health, vitality, social function, role emotional, and mental health. From these 8 dimensions, 2 composite scores can be calculated, one for physical health, the physical component summary (PCS) score, and one for mental health, the mental component summary (MCS) score.

The SF-12v2 was scored using the US algorithms given in the SF-12v2 manual [22]. Higher scores indicate better HRQoL. US comparison population norms for males and for those with a lung disability were taken from the same source [18]. For surveys missing 3 or fewer ($n = 13$) responses, we substituted the group mean for each missing response value. We excluded surveys missing 4 or more SF-12v2 responses ($N = 9$) from HRQoL analyses.

WTC cough syndrome conditions

Current WTC cough syndrome conditions—chronic cough, chronic rhinosinusitis, and GERD—were determined from questionnaire responses in the disabled and comparison groups as previously described [23]. An asthma diagnosis was determined by affirmation of current unresolved wheeze, shortness of breath and/or chest tightness ("asthma") that began after 9/11 in the disabled group and by any response except "resolved" to the question "Currently, has your asthma/RADS: resolved, feel normal when on medication/treatment; improved; stayed the same; worsened" in the comparison groups. This question was skipped by those reporting never having post-9/11 asthma.

Medications

For disabled retirees, we collected information on current and past medication use, pre- and post-9/11, although analyses for this study were limited to current asthma medications. These medications were dichotomized as daily controller medications, which are prescribed to be taken on a regular basis to control the underlying causes of airway obstruction, versus "as needed" rescue medications taken to relieve symptoms on a temporary basis. Medication use was not available for the comparison groups.

Asthma control

Based on the current NHLBI guidelines [24] and the Asthma Therapy Assessment Questionnaire (ATAQ), we used the following four questions to assess asthma control: (1) self perception of asthma from a question in which the participant reported whether their condition was cured, a lot better, somewhat better, a little better, unchanged, or worse since beginning their treatment. The next three questions asked participants how often in the past 4 weeks

their asthma caused the following: (2) limitation in normal daily activities; (3) nighttime awakenings; (4) the use of quick relief inhaler medication (not counting use for recent respiratory infections or for routine exercise). Asthma was considered to be not well controlled if normal activities were limited at all, nighttime awakenings occurred more than once per week, and quick relief inhaler medications were used more than twice per week. The number of control problems was then summed to provide an index from 0 to 4 with a score of 2 or greater indicating an overall problem with control [17]. Missing responses were scored as zero, yielding conservative estimates of poor control.

Data sources

Demographic information, including date of hire, and date of retirement, was obtained from the FDNY employee database. We obtained height and weight (to calculate BMI) and WTC exposure from information collected from the Medical Monitoring Program (FDNY-WTC-MMP) visits, which were implemented to screen active and retired FDNY rescue workers who were exposed to the WTC disaster on an on-going basis every 12–18 months [4].

WTC exposure

Exposure to the WTC site was determined using the previously described FDNY-WTC-MMP Exposure Intensity Index based on initial arrival time to the WTC site [4]. Those who first arrived during the morning of 9/11 (day 1) and were present during the tower collapses were categorized as "Arrival Group 1"; those arriving during the afternoon of 9/11 were categorized as "Arrival Group 2"; those arriving on day 2 were categorized as "Arrival Group 3"; and those who arrived at any time between days 3 through 14 were categorized as "Arrival Group 4".

Statistical analysis

Demographic characteristics of the participants were evaluated using means and standard deviations, *t*-tests, and ANOVAS for continuous variables and chi-squared analyses for frequencies and categorical variables. Relationships between the PCS score and MCS score and explanatory variable(s) were examined using multivariable linear regression models. All models adjusted for arrival group, current age, smoking status (ever vs. never), and BMI ($\geq$30 vs. $<$30). First level interaction terms were examined; none were statistically significant. A 2-tailed alpha of 0.05 was used to denote statistical significance. Statistical analyses were performed using SAS for Windows statistical software, version 9.1 (SAS Institute, Cary, NC, USA).

Results

We obtained completed interviews from 305 of 590 (51.7%) eligible retirees. Comparing participants to non-participants, participants, on average, were older (51.4 ± 6.7 vs. 49.5 ± 6.2) and had more years of service at the time of their retirement (17.4 ± 6.2 vs. 9.6 ± 6.0). Lastly, participants were less likely to be firefighters than officers and fire marshals at retirement than non-participants (OR = 0.7, 95% CI = 0.5–1.0). There were no significant differences in arrival group, duration of months spent working at the WTC site, education, or race/ethnicity.

Of the 305 who participated, 165 questionnaires (54.1%) were completed over the telephone and 140 (45.9%) by mail. Analyses excluded 20 persons who were not in arrival groups 1 through 4 or had an unknown arrival group, 9 who were missing 4 or more of 12 SF-12v2 questions, and 1 woman who was contacted in error. The final analytic sample consisted of 275 participants with a mean ($\pm$SD) of 5.4 ± 1.1 years retired. There were no significant differences in arrival group, age, years of service, duration of months worked at the site, rank, level of education, or race/ethnicity between those who completed the questionnaire over the telephone and those who completed the questionnaire through the mail. Further, we assessed mean scores by mode of administration and again found no significant differences. Mean PCS scores for telephone versus mail were 36.3 (9.8) vs. 36.5 (9.5); $P = 0.89$ and for MCS scores were 45.0 (12.2) vs. 43.8 (11.6); $P = 0.41$.

Table 1 shows unadjusted mean ($\pm$SD) PCS and MCS scores overall, by work status and by participant characteristics including WTC arrival group (all $P < 0.05$) and current WTC cough syndrome conditions. US general population norms for males were 50.6 and 50.4 for PCS and MCS, respectively [18], while norms for those with lung disease were 38.1 and 45.6 for PCS and MCS, respectively [18]. Within each level of current number of WTC-related conditions, there was no difference in mean MCS scores by work status. Within each work status, however, as the number of WTC cough syndrome conditions increased both PCS and MCS scores decreased, indicating lower HRQoL. Figure 1 shows this dose response gradient between the number of WTC cough syndrome conditions and PCS and MCS scores and by work status. This trend was found to be significant for both the PCS and MCS scores (linear test for trend both $P < 0.01$).

Table 1 Demographic and other characteristics of study participants by work status and their unadjusted mean (±SD) PCS and MCS scores and tests for significance

	Disabled firefighters			Active firefighters			Ordinary retired firefighters			*P*-value*	*P*-value*
	N	PCS	MCS	*N*	PCS (SD)	MCS (SD)	*N*	PCS (SD)	MCS (SD)	PCS	MCS
Totals	275	36.4 (9.6)	44.5 (11.9)	3,465	53.1 (5.1)	48.7 (7.4)	938	49.3 (8.7)	48.1 (8.5)	*	*
Arrival group											
1	61	34.0 (10.0)	41.5 (11.8)	505	53.2 (5.4)	47.5 (8.0)	115	49.4 (8.4)	46.8 (8.2)	*	*
2	149	37.1 (9.9)	44.9 (12.5)	2,360	53.1 (5.1)	48.8 (7.2)	467	49.4 (8.7)	47.6 (9.0)	*	*
3	45	36.2 (9.5)	46.0 (9.9)	381	53.0 (5.6)	48.9 (7.7)	186	48.7 (9.0)	49.0 (7.7)	*	*
4	20	39.1 (5.3)	47.1 (11.1)	219	53.5 (4.6)	49.2 (6.8)	170	49.5 (8.5)	49.2 (7.8)	*	0.02
BMI											
<30	147	38.3 (9.4)	44.0 (11.9)	2,652	53.2 (5.2)	48.7 (7.4)	629	50.6 (8.3)	48.0 (8.3)	*	*
≥30	128	34.2 (9.5)	44.9 (12.0)	813	53.0 (4.9)	48.6 (7.4)	309	47.2 (9.0)	48.3 (8.8)	*	*
Smoking											
Ever	81	35.1 (9.0)	42.8 (12.2)	1,029	52.8 (5.1)	48.5 (7.5)	433	48.7 (8.7)	47.9 (8.7)	*	*
Never	189	36.9 (9.9)	45.2 (11.9)	2,431	53.3 (5.1)	48.8 (7.3)	472	50.2 (8.4)	48.2 (8.2)	*	*
Current age group											
25–35	N/A	N/A	N/A	15	53.9 (3.3)	50.5 (2.9)	N/A	N/A	N/A	N/A	N/A
35–44	57	38.5 (9.2)	42.7 (11.7)	1,977	53.4 (4.8)	48.6 (7.5)	29	49.2 (10.7)	48.7 (7.4)	*	*
45–54	148	36.1 (9.8)	44.3 (11.6)	1,324	52.7 (5.5)	48.7 (7.2)	386	49.9 (8.6)	47.0 (8.7)	*	*
55–64	64	34.5 (9.4)	46.5 (12.3)	149	52.6 (5.4)	48.7 (7.3)	418	49.1 (8.5)	48.6 (8.30)	*	0.07
65–74	6	43.9 (8.2)	41.8 (17.2)	N/A	N/A	N/A	105	47.8 (9.2)	49.9 (8.3)	N/A	N/A
Symptom count											
0, 1	14	44.5 (10.3)	52.2 (10.7)	2,583	53.8 (4.4)	49.6 (6.5)	685	50.8 (7.8)	48.7 (7.8)	*	0.10
2	33	36.9 (10.3)	47.3 (11.0)	623	51.8 (6.0)	46.6 (8.5)	166	46.4 (9.5)	46.2 (9.0)	*	0.56
3	90	36.9 (8.6)	45.3 (11.9)	239	49.8 (7.0)	44.7 (9.6)	71	44.3 (9.8)	46.8 (10.6)	*	0.75
4	138	35.1 (9.7)	42.4 (11.8)	20	47.3 (8.7)	45.2 (11.7)	16	38.5 (9.2)	45.7 (13.2)	*	0.17
Asthma											
No	6	43.9 (13.6)	45.6 (10.8)	3,392	53.2 (5.0)	48.8 (7.3)	885	49.7 (8.4)	48.1 (8.3)	*	0.35
Yes	269	36.2 (9.5)	44.4 (12.0)	73	50.1 (8.1)	44.5 (9.70)	53	42.1 (10.5)	47.5 (10.4)	*	0.21
GERD											
No	85	37.7 (9.6)	46.6 (12.1)	2,432	53.8 (4.5)	49.5 (6.6)	650	50.3 (8.2)	49.1 (7.5)	*	*
Yes	190	35.8 (9.6)	43.5 (11.7)	1,033	51.6 (6.2)	46.6 (8.7)	288	47.2 (9.4)	45.9 (9.9)	*	*
WTC chronic cough											
No	38	42.1 (9.7)	50.1 (9.8)	2,928	53.5 (4.7)	49.1 (6.9)	766	50.3 (8.2)	48.3 (8.1)	*	0.25
Yes	237	35.5 (9.3)	43.6 (12.0)	537	51.2 (6.5)	46.3 (9.1)	172	44.9 (9.6)	47.0 (9.8)	*	*
Sinus											
No	70	37.3 (9.9)	47.3 (11.6)	2,083	53.9 (4.3)	49.7 (6.5)	551	51.0 (7.7)	48.7 (7.8)	*	0.02
Yes	205	36.1 (9.6)	43.5 (11.9)	1,382	52.0 (6.0)	47.1 (8.2)	387	46.9 (9.4)	47.2 (9.2)	*	*

Table 1 continued

	Disabled firefighters			Active firefighters			Ordinary retired firefighters			*P*-value*	*P*-value*
	N	PCS	MCS	*N*	PCS (SD)	MCS (SD)	*N*	PCS (SD)	MCS (SD)	PCS	MCS
Total current medications											
0–4	215	37.4	44.6							**	**
5–9	58	32.7	44.2							**	**
10+	2	30.1	36.8							**	**

* Significance at $P \leq .01$ for each category comparing the PCS and MCS scores of the disabled firefighters to the active and ordinary retired firefighters

** Significance at $P < .05$ comparing to the US population norms for males determined by a *t*-test. The US population norms were chosen because we did not have medication information for the active and ordinary retired firefighters

Only 5.9% of non-disabled retirees and 2.5% of actives reported a physician diagnosis of asthma. In contrast, almost all of the disabled retirees (98%) reported a physician diagnosis of asthma. Therefore, we examined control of asthma symptoms and its relation to HRQoL only in the disabled group. Of the patients who had asthma, many also reported other conditions, including 86.6% with WTC chronic cough, 75.5% with chronic rhinosinusitis, and 70.3% with GERD. Both PCS and MCS scores were significantly lower in the 211 (78.4%) participants with poorly controlled asthma than the 58 (21.6%) participants who were well controlled. PCS scores for those with poorly controlled averaged 34.3 ± 8.7 compared to 43.1 ± 9.2 for those who were well controlled ($P < 0.01$). MCS scores for those poorly controlled averaged 43.3 ± 11.8 compared to 48.7 ± 11.9 for those who were well controlled ($P < 0.01$). Frequencies of the individual components used to define poor control and the average PCS and MCS scores for each component can be seen in Table 2, which additionally indicates that poor control was mostly due to nighttime awakenings and interference with normal activity.

Table 3a shows multivariable linear regression models predicting PCS and MCS scores for the entire group while adjusting for work status, arrival group, current age, smoking, and BMI. Arrival group 1 was a significant factor only for MCS. Of the four WTC cough syndrome conditions, asthma was the strongest predictor of PCS but was only a modest and non-significant predictor of MCS. The other three conditions were each significant predictors of both PCS and MCS. Table 3b shows the adjusted coefficients for all terms presented in Table 3a, substituting the number of conditions for each individual condition and combining 0 and 1 condition as the reference. In this adjusted model, each additional condition was inversely associated with PCS and MCS scores.

Discussion

This study is the first to report on the health-related quality of life of firefighters who retired with new-onset respiratory conditions and pulmonary disability post-9/11. This group may represent the most severely affected FDNY survivors. Disabled retirees had significantly lower PCS and MCS scores in comparison with similarly WTC-exposed non-disabled retirees (49.3 and 48.1, respectively) and active firefighters (53.1 and 48.7). We found this difference despite having excluded recently retired firefighters from this study to limit those with potential adjustment issues that could have affected well-being in retirement [20, 21]. In multivariable models, however, we found that WTC cough syndrome conditions predict impaired HRQoL,

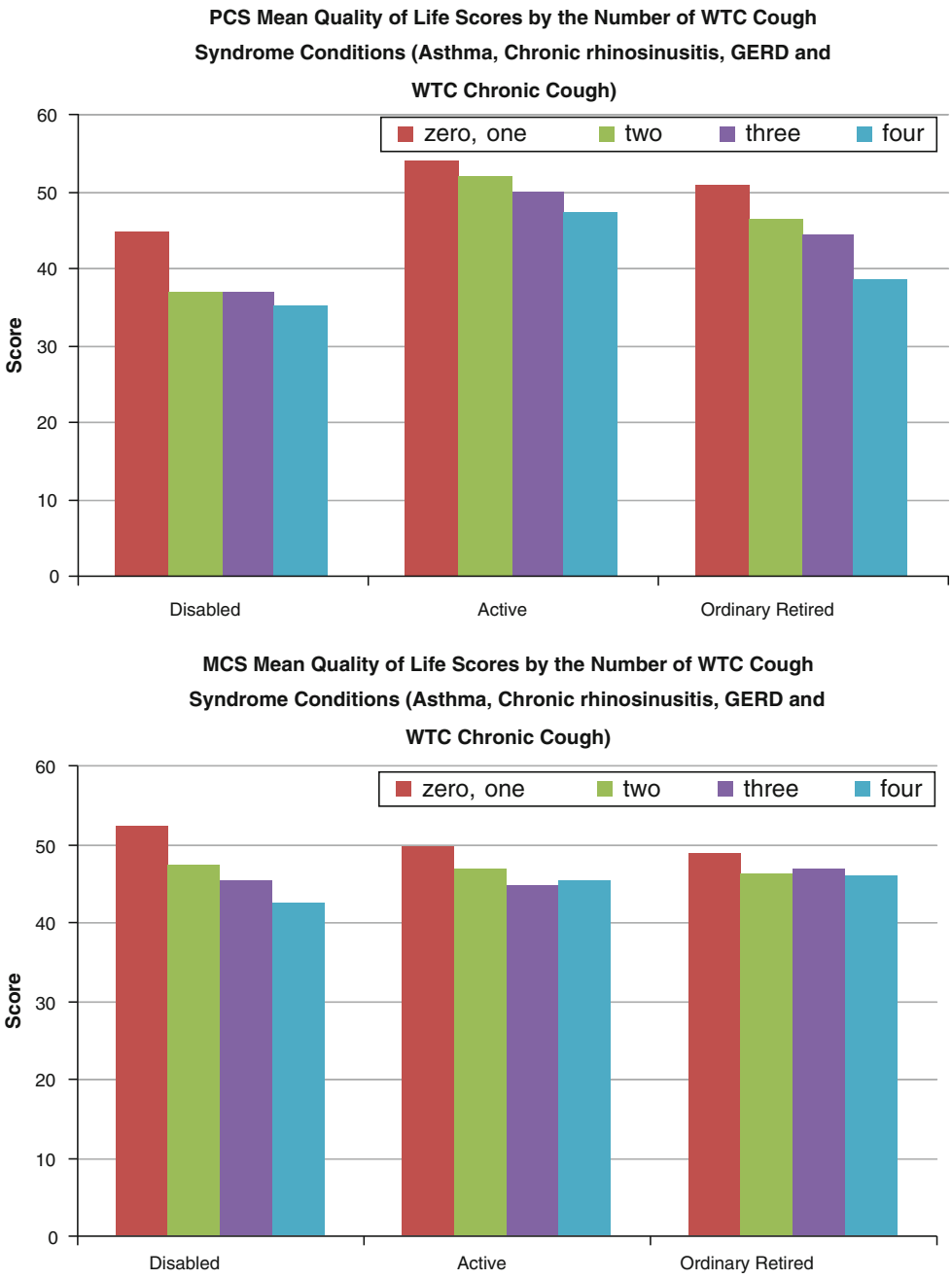

Fig. 1 Graph of PCS and MCS scores by the total number of WTC cough syndrome conditions (any combination of asthma, chronic rhinosinusitis, GERD, and/or WTC chronic cough) by work status

independent of retirement status. Further, within the same number of WTC-cough-related conditions, there were no significant differences between groups of retired or active firefighters.

Numerous studies have found inverse relationships between HRQoL and respiratory ailments, such as chronic cough, asthma, and COPD [10–14, 25]. Consistent with these findings, our data show that these respiratory ailments are associated with more than just the physical health of those diagnosed, particularly if the condition is serious. Our findings corroborate the numerous studies suggesting that HRQoL be used as an outcome indicator of well-being in those with respiratory ailments.

Some previous studies have found HRQoL to be more strongly associated with the number of symptoms for certain respiratory conditions than the severity of the underlying disease using objective measures, such as lung function [10, 11]. In multivariable models, we found that each WTC condition was associated with lower PCS and MCS scores. This could be due in part to the relationship between HRQoL and functional status [10]. An increase in the number of conditions may lead to more frequent

Table 2 Frequencies of the individual components used to define poor control and the average PCS and MCS scores for each component in disability retirees

Components of asthma control ($N = 269$)	Mean (±SD) scores					
	PCS score if poorly controlled symptom versus not			MCS score if poorly controlled symptom versus not		
	Yes	No	*P*-value	Yes	No	*P*-value
Nighttime awakenings (196 Yes, 73 No)	34.3 (9.0)	41.5 (8.9)	<0.01	42.9 (11.7)	48.4 (11.08)	<0.01
Interference with normal activity (233 Yes, 36 No)	35.1 (8.7)	43.2 (11.4)	<0.01	43.5 (12.0)	50.8 (10.0)	<0.01
Short-acting beta2-agonist use[a] (62 yes, 57 No)	33.8 (8.7)	39.0 (9.6)	<0.01	41.9 (11.3)	45.9 (11.7)	0.06
Perception of asthma as being poorly controlled[b] (107 yes, 153 No)	32.8 (8.8)	38.5 (9.3)	<0.01	42.6 (12.2)	45.9 (11.4)	0.03

[a] missing 150

[b] missing 9

interruptions of daily activities, first affecting leisure activities and potentially progressing to essential activities depending on the severity of the symptoms and natural course of the disease. Thus, the number of current aero-digestive conditions, and its effect on daily activities can be used as a marker for HRQoL. The association of a higher number of conditions with lower PCS and MCS scores highlights the importance of symptom assessment for respiratory conditions and might be also applied to other conditions or studies whose focus is on treatment and symptom amelioration.

An asthma diagnosis was the most prevalent WTC cough syndrome condition in our disabled study sample (269/275, 97.8%). Since asthma affects such a large part of this group we performed additional analyses specific to that condition. Studies in other populations have found relationships between poor asthma control and HRQoL [17, 26]. In our uniquely exposed population, we found that poor asthma control was strongly associated with lower PCS and MCS scores. Poor control was notably associated with interference with normal activities, perhaps a reflection of a retired firefighter's inability, despite medication, to adjust to new-found physical impairments. Level of control is not synonymous with severity of disease. Severity relates to the underlying pathophysiology whereas control is a better measure of symptom perception and HRQoL [17]. In our population, since all patients have access to free medical care including asthma medications, level of control likely reflects the treatment outcome rather than access to healthcare.

The finding that WTC chronic cough remained a significant predictor in both the PCS and MCS multivariable models after adjusting for work status, arrival group, current age, smoking status, and BMI is consistent with other studies that have found associations between chronic cough and lower HRQoL on both physical and psychosocial scales [12, 14, 27, 28]. It has been suggested that the decreased HRQoL in patients with chronic cough is more likely to be induced by the psychosocial component rather than the physical component [27]. This is likely due to the fact that chronic cough may have a detrimental effect on relationships with partners, family, and friends, disrupts sleep, and can cause irritability and anxiety among other physical and psychosocial factors [14]. A 1998 study by French et al. found, in multiple stepwise linear regression, that a substantial proportion of a patient's health-related dysfunction was explained by cough inducing (1) exhaustion, (2) the need for reassurance that nothing was seriously the matter with them, (3) the inability to go to the movies, and (4) spouses not being able to tolerate the cough. The same study found that successful treatment of chronic cough was associated with the resolution of their patients' deterioration in HRQoL [27]. As most medication-adherent patients can be successfully treated [27], individualized adjustment of treatment regimens is a critical component of improving HRQoL.

There are a few potential limitations to our study. First, although we had a 52% participation rate, our efforts resulted in a sample of 275 retirees who were slightly older, of a higher rank, and who had more years of service than non-participants. Both rank and years of service are closely associated with age in our study population. However, the similarity of PCS and MCS scores in our disabled retirement group to national samples of persons with lung disease adds confidence that our results were not unrepresentative. Nonetheless, we cannot rule out the possibility that non-participants were different in ways which were not assessed and that could also have affected their HRQoL. Another potential limitation is that almost all data that we used in analyses were self reported. Since these retirees were already receiving the maximum financial disability benefit, we believe it unlikely that they were inclined to exaggerate their current symptoms. It is possible, however, that some may have underestimated their

Table 3 Multivariable linear regression models showing the relationship between PCS and MCS scores and demographic and other variables

	Physical health (PCS) outcome		Mental health (MCS) outcome	
	Coeff. (SE)	*P*-value	Coeff. (SE)	*P*-value
A				
Whole group		<0.01		<0.01
Disabled firefighters[a]	−7.71 (0.66)	<0.01	−0.14 (0.84)	0.87
Active firefighters[a]	2.45 (0.29)	<0.01	1.07 (0.37)	<.01
Ordinary retired firefighters	Ref	–	Ref	–
Arrival Group 1[b]	−0.16 (0.39)	0.69	−1.65 (0.49)	<.01
Arrival Group 2[b]	−0.16 (0.33)	0.63	−0.47 (0.42)	0.26
Arrival Group 3[b]	−0.51 (0.39)	0.39	−0.09 (0.50)	0.86
Arrival Group 4	Ref	–	Ref	–
Current age	−0.08 (0.02)	<0.01	0.05 (0.02)	0.02
Smoking status (ever vs. never)	−0.54 (0.19)	<0.01	−0.41 (0.24)	0.10
BMI $\geq$ 30 (vs. BMI < 30)	−1.04 (0.20)	<0.01	0.17 (0.26)	0.51
WTC cough syndrome conditions				
Asthma DX	−3.50 (0.55)	<0.01	−0.92 (0.70)	0.19
Sinus DX	−1.36 (0.20)	<0.01	−1.53 (0.25)	<.01
Cough DX	−2.01 (0.26)	<0.01	−1.43 (0.33)	<.01
GERD DX	−1.41 (0.20)	<0.01	−2.17 (0.26)	<.01
B				
Whole group		<0.01		<0.01
Disabled firefighters[c]	−8.83 (0.54)	<0.01	0.49 (0.69)	0.48
Active firefighters[c]	2.54 (0.29)	<0.01	1.09 (0.37)	<.01
Ordinary retired firefighters	Ref	–	Ref	–
Arrival Group 1[d]	−0.17 (0.39)	0.67	−1.67 (0.49)	<.01
Arrival Group 2[d]	−0.19 (0.33)	0.57	−0.50 (0.42)	0.23
Arrival Group 3[d]	−0.51 (0.39)	0.19	−0.09 (0.50)	0.85
Arrival Group 4	Ref	–	Ref	–
Current Age	−0.08 (0.02)	<0.01	0.04 (0.02)	0.02
Smoking status (ever vs. never)	−0.51 (0.19)	<0.01	−0.39 (0.25)	0.11
BMI $\geq$ 30 (vs. BMI < 30)	−1.04 (0.20)	<0.01	0.16 (0.26)	0.54
WTC cough syndrome condition count				
0 or 1 condition	Ref	–	Ref	–
2 conditions[e]	−2.57 (0.24)	<0.01	−2.78 (0.30)	<.01
3 conditions[e]	−4.57 (0.34)	<0.01	−4.06 (0.44)	<.01
4 conditions[e]	−7.14 (0.62)	<0.01	−6.05 (0.79)	<.01

[a] Reference is group of ordinary retired firefighters

[b] Reference is arrival group 4 (arrived at WTC site 3–14 days post-9/11)

[c] Reference is group of ordinary retired firefighters

[d] Reference is arrival group 4 (arrived at WTC site 3–14 days post-9/11)

[e] Reference group is 0 or 1 WTC cough syndrome condition

current symptoms due to male stigma surrounding reporting health problems. Finally, the unique characteristics of the WTC event and our highly exposed groups of firefighters limit the generalizability of our findings.

To our knowledge, this is the first study that evaluates the relationship between HRQoL and WTC cough syndrome conditions among a 9/11-exposed population. Both the PCS and MCS scores demonstrate that firefighters diagnosed with WTC cough syndrome conditions are still lower even 8 years after exposure. This study demonstrates that current symptoms continue to predict HRQol. Our findings suggest the usefulness of routinely monitoring those who also face serious, occupational exposures to assess current symptoms and conditions. Our results would be both confirmed and extended if future studies show that reducing symptom burden with time and treatment improves HRQoL.

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