HHS Public Access
Author manuscript
Respir Med. Author manuscript; available in PMC 2020 November 01.

Published in final edited form as:
Respir Med. 2019 ; 160: 105630. doi:10.1016/j.rmed.2019.02.006.

Effects of Health Literacy and Cognitive Abilities on COPD Self-Management Behaviors: A Prospective Cohort Study

Rachel O'Conor, PhD MPH[1], **Kimberly Muellers, MPH**[2], **Marina Arvanitis, MD MPH**[1], **Daniel P Vicencio, MD**[3], **Michael S. Wolf, PhD MPH**[1], **Juan P. Wisnivesky, MD, DrPH**[2,4], **Alex D. Federman, MD, MPH**[2]

[1]Division of General Internal Medicine, Feinberg School of Medicine, Northwestern University, Chicago, Illinois

[2]Division of General Internal Medicine, Icahn School of Medicine at Mount Sinai, New York City, New York

[3]Mercy Hospital and Medical Center, Chicago, Illinois

[4]Division of Pulmonary, Critical Care and Sleep Medicine, Icahn School of Medicine at Mount Sinai, New York City, New York

Abstract

Introduction: Low rates of adherence to self-management behaviors are common among patients with COPD. Health literacy and cognitive abilities may influence engagement in self-management behaviors. We sought to assess the association between health literacy and cognitive abilities with self-management behaviors in patients with COPD.

Methods: We conducted an observational cohort study among American adults with COPD in New York, New York, and Chicago, Illinois. Outcomes included adherence to COPD medication, metered dose inhaler (MDI) and dry powder inhaler (DPI) technique, receipt of vaccination, and routine healthcare appointments. Health literacy was measured with the Short Test of Functional Health Literacy in Adults. Cognitive function was assessed in terms of global, fluid (working memory, processing speed, executive function) and crystallized (verbal) ability.

Results: Adequate health literacy was associated with adequate adherence to COPD medications (OR 1.46; 95% CI, 1.02–2.08), correct MDI (OR 1.66; 95% CI, 1.13–2.44) and DPI (OR 2.17;

Corresponding Author: Rachel O'Conor, PhD MPH, Division of General Internal Medicine & Geriatrics, Feinberg School of Medicine, Northwestern University, 750 N. Lakeshore Dr. 10th Floor, Chicago, IL 60611, United States of America, Tel. 312.503.3240, Fax 312.503.2777, r-oconor@northwestern.edu.

Author's Contributions: MSW, JPW, ADF contributed to the conception and design of the study. RO, KM, DPV contributed to the data acquisition. RO, MA, MSW, JPW, ADF contributed to the data analysis and interpretation. All authors provided critical revision for intellectual content and final approval of the manuscript.

Conflict of Interest Statement: Dr. O'Conor, Ms. Muellers, Dr. Arvanitis, Dr. Vicencio, and Dr. Federman declare they have no conflict of interest. Dr. Wolf has unrestricted research grants from Merck, Sharpe, Dohme and Eli Lily; has consulted for Luto UK and Pfizer and received honoraria from MedLearning Group, NYU. Dr. Wisnivesky has received consulting honorarium from Quintiles, AstraZenaca, Sanofi and Merck, and research grants from Sanofi and Quorum.

95% CI, 1.30–3.64) technique. Fluid abilities were also associated with medication behaviors and visiting a regular healthcare provider, while crystalized abilities were not. Global cognitive abilities were associated with correct inhaler technique. No other associations were found with non-medication self-management behaviors.

Conclusions: COPD patients with limited health literacy and deficits in fluid cognitive abilities have lower rates of adherence and poorer inhaler technique than individuals with adequate health literacy and greater fluid cognitive abilities. These findings highlight the importance of considering the health literacy level and cognitive ability when caring for and educating patients with COPD.

Keywords

self care; cognition; health literacy; chronic obstructive pulmonary disease

1. Introduction

Chronic obstructive pulmonary disease (COPD) is a leading cause of morbidity and mortality in the United States [1]. Engaging patients consistently in guideline recommended self-management behaviors is one key mechanism to reduce COPD exacerbations and subsequent hospitalizations and to improve quality of life [2]. However, COPD self-management is complex and includes appropriate use of daily medications, receipt of influenza and pneumococcal vaccination, routine appointments with healthcare providers, and when appropriate, use of supplemental oxygen [3, 4]. Despite the documented benefits of self-management, previous studies have shown that many patients are non-adherent to their COPD medications [5–7], misuse their inhalers [8], and fail to receive recommended vaccinations [9].

Health literacy, the degree to which individuals have the capacity to obtain, process and understand basic health information and services needed to make appropriate health decisions [10], as well as a more expansive set of cognitive abilities, are predictive of adherence to self-management behaviors across an array of conditions [11–14]. Limited health literacy and poorer cognitive abilities are associated with worse health outcomes among COPD patients [15–17], however their associations with COPD self-management behaviors is unknown. Cognitive abilities may be especially relevant to engagement in COPD self-care behaviors as patients with COPD are known to suffer from higher rates of cognitive impairment, likely resulting from chronic hypoxemia [18]. The objective of this investigation was to assess the association between health literacy and cognitive abilities with self-management behaviors in patients with COPD. We hypothesized that limited health literacy and poor cognitive abilities would be associated with poor self-management behaviors in patients with COPD.

2. Methods

2.1. Study Design

We conducted a prospective cohort study of adults with COPD recruited from hospital and community-based primary care and pulmonary practices in New York City, New York and

Chicago, Illinois. Patients were enrolled from November 2011 to January 2015. Potential participants were identified through queries of clinic records based on eligibility criteria that were documented within the electronic health records. After obtaining physician permission, potential participants were mailed a letter informing them about the study and provided a toll-free number to decline participation. Ten days following the initial mailing, trained bilingual research coordinators contacted participants by telephone to administer a brief eligibility screener. Interested and eligible participants were scheduled for an in-person baseline interview, during which written informed consent was obtained. All research coordinators were trained to administer all assessments included in the study battery and were required to pass a certification test before completing participant interviews. Follow-up interviews were conducted at 6, 12, 18 and 24 months.

Patients were eligible if they: 1) had a diagnosis of COPD made by a healthcare provider, 2) were ≥55 years, 3) spoke English or Spanish, and 4) were community-dwelling. We excluded patients with 1) asthma or another chronic respiratory illness, 2) a chart documented diagnosis of dementia or >2 errors on a 6-item dementia screening tool [19], and 3) any other neurological and psychological conditions that profoundly affect cognition (e.g., stroke, advanced Parkinson's disease, schizophrenia). The study was approved by the Institutional Review Boards of the Mount Sinai School of Medicine, Northwestern University Feinberg School of Medicine, and Mercy Hospital and Medical Center.

2.2. Study Outcomes

2.2.1. Medication Adherence—Adherence to COPD medications was assessed via self-report using the Medication Adherence Reporting Scale (MARS). The MARS is a validated instrument that was previously adapted to assess adherence with inhaled medications and correlates well with objective electronic-monitoring adherence measures [20]. The scale includes ten items to examine both intentional and non-intentional determinants of medication non-adherence, and the questions are framed as a negative statement to minimize social desirability bias. Each item is rated on a 5-point Likert scale with higher scores indicating greater adherence. Participants with a MARS score of ≥4.5 were classified as having adequate medication adherence, which is equivalent to never or rarely forgetting to take a medication [20–22].

2.2.2. Inhaler Technique—Participants' ability to administer their metered dose inhaler (MDI) and/or a dry powder inhaler (DPI) devices was assessed using previously validated standardized checklists [23]. The MDI and DPI assessments address 8 and 7 steps in the use of the devices, respectively, covering the essential elements for adequate drug delivery. The steps included essential elements to drug delivery from preparation of the devices to their actuation and delivery of the medications. The MDI checklist included: 1) shake inhaler and remove protective cap, 2) hold inhaler upright, 3) exhale to residual volume, 4) place mouthpiece between lips and teeth, 5) inhale slowly and simultaneously activate the canister, 6) continue slow and deep inhalation, 7) hold breath for 5–10 seconds, 8) remove inhaler from mouth. The DPI steps included: 1) prepare inhaler before usage, 2) keep inhaler horizontal, 3) exhale to residual volume, 4) place mouthpiece between lips and teeth, 5) inhale forcefully and deeply, 6) take inhaler out of the mouth, 7) hold breath for 5 seconds.

Trained interviewers observed the patients and documented the number of steps that were completed correctly. A threshold of >75% correctly completed steps was set to define adequate inhaler technique [11, 12], as a conservative mid-point that falls within a broad range of acceptable definitions of inhaler technique [8].

2.2.3. Other Self-Management Behaviors—

Participants self-reported whether they had received an influenza vaccination in the past 12 months or ever received a pneumococcal vaccination. We also obtained information regarding whether participants had a healthcare provider (pulmonologist or general internist) who oversaw their COPD care, and whether they attended routine checkups for their COPD in the past 12 months.

2.3. Study Predictors

2.3.1. Health Literacy—

Health literacy was measured using the reading comprehension section of the Short Test of Functional Health Literacy in Adults (S-TOFHLA) [24]. The S-TOFHLA is a valid and reliable assessment commonly used in health literacy research that is strongly correlated with intermediate and distal health outcomes [25]. The S-TOFHLA is validated in both English and Spanish [26] and consists of a series of health-related passages, in which every fifth or seventh word is omitted, and respondents are asked to choose the appropriate missing word from four multiple choice items. As per S-TOFHLA administration procedures, the assessment is only administered to individuals with adequate visual acuity, defined as vision ≤20/50. Prior to completing the S-TOFHLA, vision with current correction was assessed using the Snellen handheld chart following standard administration procedures. Individuals with vision worse than 20/50 were omitted. Scores range from 0 to 36, with higher scores indicating higher health literacy; participants were classified as having adequate (score ≥23) or limited (score <23) health literacy.

2.3.2. Cognitive Abilities—

Cognitive abilities were broadly classified as fluid, crystallized or global cognitive ability. Fluid abilities (processing speed, working memory, long-term memory, executive function) refer to cognitive traits associated with active information processing in which prior knowledge is of relatively little help. Processing speed was measured using the Pattern Comparison test which asks participants to compare pairs of simple line drawings that are the same or different and to complete as many trails as one can in a given time period [27]. Working memory was measured using the Size Judgement Span task, in which participants are read lists of differing amounts of randomly ordered, size-constant items and asked to reorder the items from smallest to largest [28, 29]. Delayed recall was assessed using the New York University Paragraph Recall test, which asks participants to repeat back as much of a story as possible after an approximate twenty minute delay [30]. Assessment of executive function was performed through the Trail Making Test, a test that requires respondents to connect dots on a page scattered with numbers (Trails A) or both numbers and letters (Trails B) in the appropriate sequence [31]. A latent trait for fluid ability was derived from these tests [32]. Crystallized (verbal) ability refers to stored information in long-term memory, or general background knowledge, and was measured using the animal naming task, in which participants are asked to name as many animals of any kind in one minute [33]. Global cognitive ability was assessed using the Mini Mental State Exam, which is a commonly used exam in medical settings [34]. The

MMSE includes items that assess attention, recall, calculation, orientation, and ability to follow verbal and written commands, and includes aspects of both fluid and crystallized abilities. Scores range from 0–30 and were classified as low (≤24) or adequate (>24) [34].

2.4. Covariates

Measures of age, race/ethnicity, income, and the number of self-reported chronic conditions were recorded. COPD severity was assessed with the COPD Severity Index, a validated self-report instrument based on respiratory symptoms, systemic corticosteroid use, other COPD medications, home oxygen use, hospitalizations and intubation history. Possible scores range from 0–25, with higher values indicating greater disease severity [35].

2.5. Statistical Analysis

Descriptive statistics were calculated for all participant characteristics. T-tests and chi-square statistics were used to examine differences in self-management behaviors by health literacy level and global cognitive ability. A factor score for fluid ability was created to reduce several correlated cognitive skills to one measure and to avoid multicollinearity in subsequent regression models. The summary score was created by forcing a single factor using maximum likelihood estimation. Repeated measure analyses to explore the association between health literacy and different cognitive domains with COPD self-management behaviors was conducted using generalized estimating equation (GEE) models on observations at baseline, 12 months, and 24 months. Each model was then adjusted for age, gender, race/ethnicity, income, number of comorbidities, and COPD severity. We tested for the presence of interaction due to time on the relationship between cognition and health literacy within each model. We did not observe a significant interaction term and therefore did not include an adjustment for time in our final analyses. Medication adherence analyses were limited to individuals prescribed a COPD medication (n=337), inhaler technique was limited to individuals prescribed a metered dose inhaler (n=338) or a dry powder inhaler (n=198).

3. Results

We identified 1098 patients, successfully contacted 927 by telephone, and screened 618, of whom 482 were eligible. Of these, 393, 333, and 299 completed the baseline, 12-month, and 24-month interviews, respectively. Among those who did not complete their 24-month interview, 31 were deceased, 15 declined participation, and 48 were unable to be contacted. Participants who did not complete the 24-month interview were more likely to be older, identify as Hispanic, speak Spanish, have lower educational attainment, inadequate health literacy, and more severe COPD, and chronic conditions at baseline (p's<0.05). The average age of participants was 68 years, the majority were non-white (43.8% African American, 16.5% Hispanic), had a high school education or less (47.7%), and low-income (48.2% < $1350/month) (Table 1). Participants had an average of four comorbidities (M=3.6, SD=1.8), and the average (SD) COPD severity score was 7.31 (±5.7). Nearly a third (28.5%) of the sample was classified as having limited health literacy. A total of 37.7% were classified as having cognitive impairment according to their MMSE score.

At baseline, 38.9% of participants were adherent with their COPD medication, 66.9% demonstrated correct metered dose inhaler technique, and 52.5% demonstrated correct technique for using their dry powder inhaler (Table 2). The majority (78.9%) reported receiving the influenza vaccination in the past 12 months, and 81.9% reported receiving the pneumococcal vaccination. Most respondents, 80.6%, identified a regular healthcare provider who managed their COPD care, and 59.2% had a routine visit for COPD in the past 12 months.

In bivariable analyses, compared with individuals with adequate health literacy, participants with limited health literacy were less likely to be adherent to their COPD medicines (23.3% vs. 46.0%, $p<0.001$), demonstrate correct MDI (57.8% vs. 71.9%, $p=0.02$) or DPI (40.0% vs. 56.7%, $p=0.04$) technique, or have one healthcare provider regularly manage their COPD (71.8% vs. 84.2%, $p=0.02$; Table 2). We did not observe significant differences between patients with adequate and limited health literacy for rates of influenza (75.0% vs. 80.0%, $p=0.41$) and pneumococcal (81.9% vs. 79.0%, $p=0.62$) vaccination, or routine visits with healthcare providers (53.9% vs. 62.5%, $p=0.22$). Similar results were found by global cognitive ability score (Table 2).

In unadjusted repeated measures analyses, health literacy and global cognitive ability were associated with medication adherence, and correct MDI and DPI technique (Table 3). Global cognitive ability was also associated with influenza vaccination. Fluid abilities were associated with all self-management behaviors, except vaccination uptake, while crystallized abilities were solely associated with correct MDI technique and influenza vaccination in the past 12 months.

In adjusted analyses (Table 3), adequate health literacy was independently associated with adequate adherence to COPD medications (OR 1.46; 95% CI, 1.02–2.08), and correct MDI (OR 1.66; 95% CI, 1.13–2.44) and DPI (OR 2.17; 95% CI, 1.30–3.64) technique. Similarly, fluid ability was an independent predictor of medication adherence (OR 1.74; 95% CI, 1.37–2.21), correct MDI (OR 1.59; 95% CI 1.27–1.98) and DPI (OR 1.47; 95% CI, 1.08–2.00) technique, and visiting a COPD healthcare provider in the past 12 months (OR 1.42; 95% CI 1.01, 1.99). Conversely, crystallized ability was not associated with adequate medication adherence (OR 0.93; 95% CI, 0.67–1.27), MDI technique (OR 1.30; 95% CI, 0.93–1.81), or DPI (OR 0.92; 95% CI, 0.58–1.47) technique. Global cognitive ability was predictive of correct MDI and DPI technique. Health literacy, fluid cognitive abilities or crystallized abilities, or global cognitive ability were not associated with having a regular healthcare provider, receipt of the influenza or pneumococcal vaccination.

Further investigation of subdomains of fluid cognitive abilities (Table 3) found greater immediate and delayed recall and processing speed were predictive of adequate medication adherence and correct inhaler technique.

4. Discussion

In this multi-site cohort study of patients with COPD, we found a large proportion of participants were not adherent with their COPD medication regimen, and nearly half

Author Manuscript

Author Manuscript

Author Manuscript

demonstrated poor inhaler technique. We also found that worse health literacy and fluid cognitive abilities were consistently associated with medication non-adherence and incorrect inhaler technique. These findings add to an existing body of research documenting associations between limited health literacy and poor health outcomes among COPD patients [15], but had not examined associations between health literacy and intermediary outcomes, such as self-management behaviors that could serve as points of intervention. Our findings suggest that low adherence and inhaler technique may be important contributors along the causal pathways between limited health literacy and poor COPD outcomes and offers points of intervention for COPD self-management programs. Our findings also add to a growing body of literature that posits the construct of health literacy represents a broader cognitive skill set [11, 36]. Numerous definitions and conceptual models of health literacy exist, Sorensen and colleagues identified 17 definitions and 12 conceptual models [37], and these finding suggest that cognitive abilities may be critical components.

We found that verbal ability, or more generalized knowledge, was not associated with COPD self-management behaviors, while fluid cognitive abilities, or an individual's ability to actively learn and process new information were predictive of core COPD self-management behaviors including medication adherence and inhaler technique. These findings are notable, especially among a sample of older adults as fluid abilities decline over the lifecourse, while crystallized verbal abilities remain stable [38]. We could expect that as patients with COPD continue to age, they will experience greater difficulty with fluid cognitive abilities. Furthermore, immediate and delayed recall and processing speed were consistently predictive of these self-management behaviors. These findings suggest that patients may initially comprehend new information while within a healthcare encounter but they may have difficulty later recalling this information when they return home and must execute these behaviors. Additionally, patients may experience difficulty processing medical information presented to them in a rapid verbal interaction, which is commonplace during healthcare encounters.

Our findings support the need to incorporate health literacy and cognitive science best-practices in managing patients with COPD. Self-management education materials for this population should be designed with features that support understanding of printed materials (e.g., low reading grade level, single concept per line, concrete instructions) [39–41]. A multi-step behavior should be 'chunked' into small steps in order to promote understanding. For example, inhaler technique could be chunked into three sections: (1) get your inhaler READY: shake the inhaler, remove the cap, and put the open end in the spacer; (2) SET your mouth to use your inhaler: breathe out slowly and put your lips around the mouthpiece; and (3) GO: push down on the inhaler and breathe in slowly [11, 42]. Teach-to-goal is an additional strategy which promotes understanding of new material or skills by asking patients to repeat in their own words the new information and if necessary re-teach the information [43]. A brief teach-to-goal intervention on MDI and DPI technique was found to be a successful strategy to improve inhaler technique [44]; however a follow-up study found that while the teach-to-goal intervention was able to reduce rates of misuse, the rates of misuse did increase between 30 and 90 day follow-up [45], suggesting additional forms of intervention are likely needed. The incorporation of tangible print memory prompts may facilitate recall during spoken counseling sessions [41]. As time for patient education and counseling is generally limited to routine clinical encounters, these efforts need to be tailored to maximize both time-efficiency and efficacy. Our study team is currently evaluating the effectiveness of a patient-tailored intervention for adults with asthma using low literacy best practices and educational materials [46]; if successful, those interventions could also be applied to patients with COPD. Lastly, a recent systematic review of self-management interventions for individuals with low health literacy found that the most effective interventions focused on three or four self-management skills (problem-solving, taking action, decision-making, partnership, resource utilization), while interventions that incorporated five aspects of less than three were not as effective. These findings support the need for multi-faceted approaches for individuals with low health literacy, but also suggest that addressing too many items may be overwhelming without sufficient time to develop these new skills [47].

We found that more than 60% of participants in our study were non-adherent to their COPD regimen. The non-adherence rate in our cohort exceeded rates reported in other studies based on similar self-report measures [48, 49] but is below more recent studies that calculated medication adherence based on pharmacy refill data [6, 7]. As studies have begun to compare adherence rates across conditions, there is growing evidence that adherence to inhaled COPD or asthma medications is lower than that of pill-form medications [6, 7, 50]. This discrepancy may be due to greater complexity of inhaler use, which requires multiple steps and coordinated actions, compared to the simpler task of taking tablets or capsules [51]. Furthermore, due to the variety of inhalation devices, COPD patients must familiarize themselves with the different steps and actions required for each inhaler prescribed for them. Due to the complexity of these devices, older patients with cognitive impairments may receive greater therapeutic benefit from nebulizers for drug delivery [52]. An additional cause of the discrepancy between inhaler and pill adherence may be the relatively greater monthly costs of inhalers, for which no generic options exist [53, 54]. Among our sample of older adults, Medicare was a primary source of insurance; in 2015 the average annual out-of-pocket costs of one inhaler was $900. Many patients with COPD have two or three inhalers, raising annual costs to approximately $1600 and $2800 annually [55]. These are substantial costs for the sample of COPD patients in our study, about half of whom reported household incomes near or below the federal poverty level.

We did not find significant associations between health literacy or cognitive abilities with other self-management behaviors such as receipt of vaccines or routine visits with a healthcare provider. The lack of association may be due to the fact that these outcomes reflect behaviors that are less frequent, less cognitively complex and more likely to be influenced by quality improvement initiatives within health systems. Sampling bias may also have contributed to this observation since we recruited patients through clinical practices and were therefore already engaged in regular clinical care.

Our findings should be considered in the context of some methodological limitations. First, most of the outcomes we studied (medication adherence, vaccination and health services) were measured by self-report, which is subject to recall bias—a serious concern for a study focusing on cognitive ability. However, we took special precautions to limit recall bias by conducting frequent interviews to shorten the lookback period and using an adherence measure that refers to recent use of medications. Additionally, the medication adherence assessment that we used was designed to minimize social desirability bias, and given that 60% of our participants reported poor medication adherence, we do not suspect that the measure led to significant over-reporting of adherence. Second, our sample was recruited from urban medical practices so our findings may not be generalizable to patients living in non-urban areas. Third, a team of research coordinators completed the interviews with participants over the 24-month period, and one interviewer observed inhaler technique, and therefore observer bias may have been present. To mitigate this possibility, research coordinators were required to pass a certification test before beginning interviews with participants, and study staff held regular meetings to ensure accurate scoring of all assessments. Lastly, we did not report on use of supplemental oxygen and smoking cessation, two important components of COPD self-management.

5. Conclusion

In conclusion, COPD patients with limited health literacy and deficits in fluid cognitive abilities have lower rates of adherence and poorer inhaler technique than individuals with adequate health literacy and greater fluid cognitive abilities. These findings highlight the importance of considering the health literacy level and cognitive ability when caring for and educating patients with COPD.

Acknowledgments

Funding: This work was supported by the National Heart, Lung and Blood Institute (R01HL105385).

REFERENCES

[1]. Heron M, National vital statistics reports, National Vital Statistics Reports 64(10) (2015).

[2]. Zwerink M, Brusse‐Keizer M, van der Valk PD, Zielhuis GA, Monninkhof EM, van der Palen J, Frith PA, Effing T, Self management for patients with chronic obstructive pulmonary disease, The Cochrane Library (2014).

[3]. Qaseem A, Wilt TJ, Weinberger SE, Hanania NA, Criner G, van der Molen T, Marciniuk DD, Denberg T, Schünemann H, Wedzicha W, Diagnosis and management of stable chronic obstructive pulmonary disease: a clinical practice guideline update from the American College of Physicians, American College of Chest Physicians, American Thoracic Society, and European Respiratory Society, Ann Intern Med 155(3) (2011) 179–191. [PubMed: 21810710]

[4]. Vestbo J, Hurd SS, Agustí AG, Jones PW, Vogelmeier C, Anzueto A, Barnes PJ, Fabbri LM, Martinez FJ, Nishimura M, Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease: GOLD executive summary, Am J Respir Crit Care Med 187(4) (2013) 347–365. [PubMed: 22878278]

[5]. George J, Kong DC, Thoman R, Stewart K, Factors associated with medication nonadherence in patients with COPD, CHEST 128(5) (2005) 3198–3204. [PubMed: 16304262]

[6]. Dhamane AD, Schwab P, Hopson S, Moretz C, Annavarapu S, Burslem K, Renda A, Kaila S, Association between adherence to medications for COPD and medications for other chronic conditions in COPD patients, Int J Chron Obstruct Pulmon D 12 (2017) 115–122.

[7]. Neugaard BI, Priest JL, Burch SP, Cantrell CR, Foulis PR, Quality of care for veterans with chronic diseases: performance on quality indicators, medication use and adherence, and health care utilization, Popul Health Manag 14(2) (2011) 99–106. [PubMed: 21091367]

[8]. Press VG, Arora VM, Shah LM, Lewis SL, Ivy K, Charbeneau J, Badlani S, Nareckas E, Mazurek A, Krishnan JA, Misuse of respiratory inhalers in hospitalized patients with asthma or COPD, J Gen Intern Med 26(6) (2011) 635–42. [PubMed: 21249463]

[9]. Hsu DJ, North CM, Brode SK, Celli BR, Identification of Barriers to Influenza Vaccination in Patients with Chronic Obstructive Pulmonary Disease: Analysis of the 2012 Behavioral Risk Factors Surveillance System, Chronic Obstr Pulm Dis 3(3) (2016) 620–627. [PubMed: 27981230]

[10]. Institute of Medicine, Health literacy: A prescription to end confusion, National Academy Press, Washington DC, 2004.

[11]. O'Conor R, Wolf MS, Smith SG, Martynenko M, Vicencio DP, Sano M, Wisnivesky JP, Federman AD, Health literacy, cognitive function, proper use, and adherence to inhaled asthma controller medications among older adults with asthma, CHEST 147(5) (2015) 1307–15. [PubMed: 25275432]

[12]. Federman AD, Wolf MS, Sofianou A, Martynenko M, O'Connor R, Halm EA, Leventhal H, Wisnivesky JP, Self-management behaviors in older adults with asthma: associations with health literacy, J Am Geriatr Soc 62(5) (2014) 872–9. [PubMed: 24779482]

[13]. Stilley CS, Bender CM, Dunbar-Jacob J, Sereika S, Ryan CM, The impact of cognitive function on medication management: Three studies, Health Psychol 29(1) (2010) 50–55. [PubMed: 20063935]

[14]. Park DC, Hertzog C, Leventhal H, Morrell RW, Leventhal E, Birchmore D, Martin M, Bennett J, Medication adherence in rheumatoid arthritis patients: older is wiser, J Am Geriatr Soc 47(2) (1999) 172–183. [PubMed: 9988288]

[15]. Omachi TA, Sarkar U, Yelin EH, Blanc PD, Katz PP, Lower health literacy is associated with poorer health status and outcomes in chronic obstructive pulmonary disease, J Gen Intern Med 28(1) (2013) 74–81. [PubMed: 22890622]

[16]. Dodd JW, Charlton RA, van den Broek MD, Jones PW, Cognitive dysfunction in patients hospitalized with acute exacerbation of COPD, CHEST 144(1) (2013) 119–127. [PubMed: 23349026]

[17]. Roncero C, Campuzano AI, Quintano JA, Molina J, Perez J, Miravitlles M, Cognitive status among patients with chronic obstructive pulmonary disease, Int J Chron Obstruct Pulmon Dis 11 (2016) 543–51. [PubMed: 27042043]

[18]. Thakur N, Blanc PD, Julian LJ, Yelin EH, Katz PP, Sidney S, Iribarren C, Eisner MD, COPD and cognitive impairment: the role of hypoxemia and oxygen therapy, Int J Chron Obstruct Pulmon Dis 5 (2010) 263–269. [PubMed: 20856825]

[19]. Callahan CM, Unverzagt FW, Hui SL, Perkins AJ, Hendrie HC, Six-item screener to identify cognitive impairment among potential subjects for clinical research, Med Care 40(9) (2002) 771–81. [PubMed: 12218768]

[20]. Cohen JL, Mann DM, Wisnivesky JP, Horne R, Leventhal H, Musumeci-Szabó TJ, Halm EA, Assessing the validity of self-reported medication adherence among inner-city asthmatic adults: the Medication Adherence Report Scale for Asthma, Annals of Allergy, Asthma & Immunology 103(4) (2009) 325–331.

[21]. Wisnivesky JP, Kattan M, Evans D, Leventhal H, Musumeci-Szabo TJ, McGinn T, Halm EA, Assessing the relationship between language proficiency and asthma morbidity among inner-city asthmatics, Med. Care 47(2) (2009) 243–9. [PubMed: 19169126]

[22]. Roy A, Lurslurchachai L, Halm EA, Li XM, Leventhal H, Wisnivesky JP, Use of herbal remedies and adherence to inhaled corticosteroids among inner-city asthmatic patients, Ann Allergy Asthma Immunol 104(2) (2010) 132–8. [PubMed: 20306816]

[23]. van Beerendonk I, Mesters I, Mudde AN, Tan TD, Assessment of the inhalation technique in outpatients with asthma or chronic obstructive pulmonary disease using a metered-dose inhaler or dry powder device, J Asthma 35(3) (1998) 273–9. [PubMed: 9661680]

[24]. Nurss JR, Parker RM, Williams MV, Baker DW, TOFHLA. Test of Functional Health Literacy in Adults, Peppercorn Books and Press, Snow Camp, 2003.

[25]. Berkman ND, Sheridan SL, Donahue KE, Halpern DJ, Crotty K, Low health literacy and health outcomes: an updated systematic review, Annals of Internal Medicine 155(2) (2011) 97–107. [PubMed: 21768583]

[26]. Baker DW, Williams MV, Parker RM, Gazmararian JA, Nurss J, Development of a brief test to measure functional health literacy, Patient Educ Couns 38(1) (1999) 33–42. [PubMed: 14528569]

[27]. Salthouse TA, Babcock RL, Decomposing adult age differences in working memory, Dev Psychol 27(5) (1991) 763.

[28]. Cherry KE, Elliott EM, Reese CM, Age and individual differences in working memory: the size judgment span task, J Gen Psychol 134(1) (2007) 43–65. [PubMed: 17283854]

[29]. Cherry KE, Park DC, Individual difference and contextual variables influence spatial memory in younger and older adults, Psychol Aging 8(4) (1993) 517–26. [PubMed: 8292280]

[30]. Kluger A, Ferris SH, Golomb J, Mittelman MS, Reisberg B, Neuropsychological prediction of decline to dementia in nondemented elderly, J Geriatr Psychiatry Neurol 12(4) (1999) 168–79. [PubMed: 10616864]

[31]. Spreen O, Strauss E, A compendium of neuropsychologial tests, Administration, norms, and commentary, Oxford University Press Oxford 1998.

[32]. Wolf MS, Curtis LM, Wilson EAH, Rivelle W, Waite KR, Smith SG, Weintraub S, Borosh B, Rapp DN, Park DC, Deary IC, Baker DW, Literacy, Cognitive Function, and Health: Results of the LitCog Study, J Gen Intern Med 27(10) (2012) 1300–7. [PubMed: 22566171]

[33]. Prince MJ, Macdonald AM, Sham PC, Richards M, Quraishi S, Horn I, The development and initial validation of a telephone-administered cognitive test battery (TACT), Int J Methods Psychiatr Res 8(1) (1999) 49–57.

[34]. Folstein MF, Folstein SE, McHugh PR, "Mini-mental state": a practical method for grading the cognitive state of patients for the clinician, J Psychiatr R12(3) (1975) 189–198.

[35]. Eisner MD, Trupin L, Katz PP, Yelin EH, Earnest G, Balmes J, Blanc PD, Development and validation of a survey-based COPD severity score, CHEST 127(6) (2005) 1890–7. [PubMed: 15947299]

[36]. Wolf MS, Curtis LM, Wilson EA, Revelle W, Waite KR, Smith SG, Weintraub S, Borosh B, Rapp DN, Park DC, Deary IC, Baker DW, Literacy, cognitive function, and health: results of the LitCog study, J Gen Intern Med 27(10) (2012) 1300–7. [PubMed: 22566171]

[37]. Sørensen K, Van den Broucke S, Fullam J, Doyle G, Pelikan J, Slonska Z, Brand H Health literacy and public health: A systematic review and integration of definitions and models, 12(1) (2012) 80.

[38]. Park DC, Lautenschlager G, Hedden T, Davidson NS, Smith AD, Smith PK, Models of visuospatial and verbal memory across the adult life span, Psychol Aging 17(2) (2002) 299. [PubMed: 12061414]

[39]. Doak CC, Doak LG, Root JH, Teaching patients with low literacy skills, Lippincott 1985.

[40]. Baker DW, DeWalt DA, Schillinger D, Hawk V, Ruo B, Bibbins-Domingo K, Weinberger M, Macabasco-O'Connell A, Pignone M, "Teach to goal": theory and design principles of an intervention to improve heart failure self-management skills of patients with low health literacy, J Health Commun 16 Suppl 3 (2011) 73–88. [PubMed: 21951244]

[41]. Wilson EA, Park DC, Curtis LM, Cameron KA, Clayman ML, Makoul G, Vom Eigen K, Wolf MS, Media and memory: the efficacy of video and print materials for promoting patient education about asthma, Patient Educ Couns 80(3) (2010) 393–8. [PubMed: 20688454]

[42]. Sobel RM, Paasche-Orlow MK, Waite KR, Rittner SS, Wilson EA, Wolf MS, Asthma 1–2-3: a low literacy multimedia tool to educate African American adults about asthma, J Community Health 34(4) (2009) 321–7. [PubMed: 19353250]

[43]. Schillinger D, Piette J, Grumbach K, Wang F, Wilson C, Daher C, Leong-Grotz K, Castro C, Bindman AB, Closing the loop: physician communication with diabetic patients who have low health literacy, Arch Intern Med 163(1) (2003) 83–90. [PubMed: 12523921]

[44]. Press VG, Arora VM, Shah LM, Lewis SL, Charbeneau J, Naureckas ET, Krishnan JA, Teaching the use of respiratory inhalers to hospitalized patients with asthma or COPD: a randomized trial, J Gen Intern Med 27(10) (2012) 1317–25. [PubMed: 22592354]

[45]. Press VG, Arora VM, Trela KC, Adhikari R, Zadravecz FJ, Liao C, Naureckas E, White SR, Meltzer DO, Krishnan JA, Effectiveness of Interventions to Teach Metered-Dose and Diskus Inhaler Techniques. A Randomized Trial, 13(6) (2016) 816–824.

[46]. Federman AD, Martynenko M, O'Conor R, Kannry J, Karp A, Lurio J, Hoy-Rosas J, Lopez R, Obiapi R, Young E, Wolf MS, Wisnivesky JP, Rationale and design of a comparative

effectiveness trial of home- and clinic-based self-management support coaching for older adults with asthma, Contemp Clin Trials 44 (2015) 103–111. [PubMed: 26238181]

[47]. Schaffler J, Leung K, Tremblay S, Merdsoy L, Belzile E, Lambrou A, Lambert SD, The Effectiveness of Self-Management Interventions for Individuals with Low Health Literacy and/or Low Income: A Descriptive Systematic Review, J Gen Intern Med 33(4) (2018) 510–523. [PubMed: 29427178]

[48]. Khdour MR, Hawwa AF, Kidney JC, Smyth BM, McElnay JC, Potential risk factors for medication non-adherence in patients with chronic obstructive pulmonary disease (COPD), Eur J Clin Pharmacol 68(10) (2012) 1365–73. [PubMed: 22476392]

[49]. Dolce JJ, Crisp C, Manzella B, Richards JM, Hardin JM, Bailey WC, Medication adherence patterns in chronic obstructive pulmonary disease, CHEST 99(4) (1991) 837–41. [PubMed: 2009784]

[50]. Goodman ER, Federman AD, Martynenko M, O’Conor R, Wolf MS, Wisnivesky JP, Adherence to Multiple Medications in Older Adults with Asthma, J Am Geriatr Soc 64(5) (2016) 1133–5. [PubMed: 27225365]

[51]. George J, Phun YT, Bailey MJ, Kong DC, Stewart K, Development and validation of the medication regimen complexity index, Ann Pharmacother 38(9) (2004) 1369–76. [PubMed: 15266038]

[52]. Taffet GE, Donohue JF, Altman PR, Considerations for managing chronic obstructive pulmonary disease in the elderly, Clin Interv Aging 9 (2013) 23–30. [PubMed: 24376347]

[53]. Rosenthal E, The soaring cost of a simple breath, New York Times 12 (2013).

[54]. Hendeles L, Colice GL, Meyer RJ, Withdrawal of albuterol inhalers containing chlorofluorocarbon propellants, N Engl J Med 356(13) (2007) 1344–1351. [PubMed: 17392304]

[55]. Tseng C, Yazdany J, Dudley R, DeJong C, Kazi D, Chen R, Lin G, Medicare Part D Plans’ Coverage and Cost-Sharing for Acute Rescue and Preventive Inhalers for Chronic Obstructive Pulmonary Disease, JAMA Intern Med 177(4) (2017) 585–588. [PubMed: 28241217]

Author Manuscript
Author Manuscript
Author Manuscript

Highlights

- Limited health literacy was associated with poor adherence to COPD medications and poor inhaler technique.
- Fluid cognitive abilities, or an individual's ability to actively learn and process new information, were associated with medication adherence and inhaler technique.
- Health literacy and cognitive abilities were not associated with other self-management behaviors such as receipt of vaccines or routine visits with a healthcare provider.

Table 1.

Demographic Characteristics of Study Participants at Baseline

Variable	All Participants (N=388)
Age, Mean (SD)	68.0 (8.3)
Female, %	58.3
Race, %	
White, non-Hispanic	37.1
African-American, non-Hispanic	43.8
Hispanic	16.5
Other	2.6
Education, %	
Some High School or less	25.8
High School Graduate	21.9
Some College	24.2
≥ College Graduate	28.1
Household Income, %	
<$1350 per month	48.2
Limited Health Literacy, %	28.5
Low MMSE Score, %	37.7
No. Chronic Conditions, Mean (SD)	3.7 (1.8)
COPD Severity Score (0–26), Mean (SD)	7.3 (5.7)

Table 2.

Association between health literacy and self-management behaviors at baseline

		Health Literacy			Global Cognitive Ability		
Variable	**All Participants %**	**Adequate %**	**Limited %**	**P Value**	**Adequate %**	**Limited %**	**P Value**
Adherent to COPD medication	38.9	46.0	23.3	<0.001	45.5	27.4	0.001
Correct Inhaler Technique							
Metered dose inhaler	66.7	71.9	57.8	0.02	71.3	59.0	0.02
Dry powder inhaler	52.5	56.7	40.0	0.04	58.6	41.4	0.02
Vaccination							
Influenza in past 12 months	78.9	80.0	75.0	0.41	81.6	74.5	0.18
Pneumococcal	81.9	81.9	79.0	0.62	85.3	76.4	0.08
COPD monitoring							
Have one regular COPD doctor	80.6	84.2	71.8	0.01	84.1	74.7	0.02
Regular visit past 12 months	59.2	62.5	53.9	0.22	63.4	52.1	0.07

Table 3.

Unadjusted and adjusted association of COPD self-management behaviors with health literacy and cognition

	Medication Adherence	Correct use of Metered-Dose Inhaler	Correct use of Dry-Powder Inhaler	Regular COPD healthcare provider	Visit with Regular COPD healthcare provider in past 12 months	Influenza Vaccination	Pneumococcal Vaccination
	OR (95% CI), unadjusted adjusted	**OR (95% CI), unadjusted adjusted**	**OR (95% CI), unadjusted adjusted**	**OR (95% CI), unadjusted adjusted**	**OR (95% CI), unadjusted adjusted**	**OR (95% CI), unadjusted adjusted**	**OR (95% CI), unadjusted adjusted**
Adequate Health Literacy	1.71 (1.24, 2.37)†	1.86 (1.30, 2.67)‡	2.05 (1.31, 3.22)†	1.46 (0.99, 2.15)	1.44 (0.84, 2.47)	0.98 (0.78, 1.24)	0.89 (0.58, 1.37)
	1.46 (1.02, 2.08)*	1.66 (1.13, 2.44)†	2.17 (1.30, 3.64)†	1.13 (0.73, 1.76)	1.26 (0.70, 2.25)	0.85 (0.62, 1.18)	1.01 (0.64, 1.60)
Global cognitive ability	1.63 (1.21, 2.19)†	1.91 (1.41, 2.59)‡	1.80 (1.18, 2.75)†	1.15 (0.83, 1.60)	1.98 (1.21, 3.23)†	1.09 (0.77, 1.54)	1.10 (0.78, 1.54)
	1.31 (0.92, 1.85)	1.75 (1.25, 2.47)†	1.68 (1.05, 2.69)*	0.88 (0.61, 1.28)	1.15 (0.83, 1.60)	0.98 (0.67, 1.43)	1.17 (0.85, 1.62)
Crystallized cognitive ability	1.08 (0.81, 1.43)	1.46 (1.07, 2.00)*	0.96 (0.61, 1.50)	1.06 (0.74, 1.52)	1.34 (0.78, 2.30)	1.31 (1.00, 1.71)*	1.07 (0.77, 1.49)
	0.93 (0.67, 1.27)	1.30 (0.93, 1.81)	0.92 (0.58, 1.47)	0.86 (0.58, 1.27)	1.04 (0.58, 1.88)	1.28 (0.96, 1.71)	1.11 (0.79, 1.56)
Fluid cognitive ability	1.74 (1.44, 2.10)‡	1.53 (1.27, 1.84)‡	1.28 (1.00, 1.63)*	1.30 (1.08, 1.58)†	1.45 (1.11, 1.90)†	0.96 (0.78, 1.17)	1.03 (0.84, 1.26)
	1.74 (1.37, 2.21)‡	1.59 (1.27, 1.98)‡	1.47 (1.08, 2.00)*	1.12 (0.86, 1.46)	1.42 (1.01, 1.99)*	0.84 (0.62, 1.14)	1.20 (0.90, 1.59)
Executive Function							
Trail Making Test A	1.45 (0.97, 2.17)	2.44 (1.72, 3.47)‡	1.79 (1.00, 3.21)	1.65 (1.06, 2.56)*	3.30 (1.88, 5.77)‡	1.08 (0.78, 1.50)	1.00 (0.68, 1.47)
	1.35 (0.86, 2.12)	2.37 (1.64, 3.42)‡	1.78 (0.98, 3.21)	1.47 (0.91, 2.37)	3.05 (1.69, 5.50)‡	1.01 (0.67, 1.51)	1.18 (0.71, 1.95)
Trail Making Test B	1.49 (1.03, 2.15)*	2.10 (1.50, 2.96)‡	1.38 (0.84, 2.27)	1.31 (0.89, 1.93)	2.94 (1.72, 5.01)‡	1.01 (0.73, 1.40)	0.71 (0.46, 1.10)
	1.21 (0.79, 1.86)	1.91 (1.33, 2.76)‡	1.40 (0.80, 2.42)	1.03 (0.67, 1.58)	2.85 (1.47, 5.53)†	0.90 (0.63, 1.26)	0.80 (0.47, 1.34)
Memory							

	Medication Adherence	Correct use of Metered-Dose Inhaler	Correct use of Dry-Powder Inhaler	Regular COPD healthcare provider	Visit with Regular COPD healthcare provider in past 12 months	Influenza Vaccination	Pneumococcal Vaccination
	OR (95% CI), unadjusted adjusted	OR (95% CI), unadjusted adjusted	OR (95% CI), unadjusted adjusted	OR (95% CI), unadjusted adjusted	OR (95% CI), unadjusted adjusted	OR (95% CI), unadjusted adjusted	OR (95% CI), unadjusted adjusted
NYU Paragraph Immediate	1.17 (1.11, 1.23)‡	1.08 (1.03, 1.14)†	1.08 (1.01, 1.16)*	1.07 (1.00, 1.13)*	1.02 (0.94, 1.12)	0.97 (0.92, 1.03)	1.05 (1.00, 1.10)
	1.14 (1.07, 1.21)‡	1.06 (1.00, 1.13)*	1.09 (1.00, 1.19)*	0.99 (0.93, 1.07)	1.00 (0.90, 1.11)	0.94 (0.88, 1.00)	1.06 (1.00, 1.11)*
NYU Paragraph Delayed	1.13 (1.08, 1.18)‡	1.09 (1.04, 1.15)‡	1.07 (1.01, 1.14)*	1.07 (1.01, 1.13)*	1.07 (0.99, 1.16)	1.01 (0.96, 1.06)	1.04 (1.00, 1.08)
	1.11 (1.05, 1.17)‡	1.09 (1.03, 1.15)*	1.08 (1.00, 1.17)*	1.01 (0.95, 1.08)	1.06 (0.97, 1.15)	0.97 (0.91, 1.03)	1.06 (1.00, 1.11)*
Working memory	1.68 (1.38, 2.04)‡	1.27 (1.03, 1.57)*	1.28 (0.96, 1.70)	1.32 (1.07, 1.64)*	1.40 (1.05, 1.86)*	0.88 (0.71, 1.09)	0.97 (0.81, 1.17)
	1.55 (1.23, 1.94)‡	1.18 (0.93, 1.48)	1.24 (0.89, 1.72)	1.14 (0.88, 1.47)	1.28 (0.90, 1.81)	0.84 (0.65, 1.07)	1.02 (0.83, 1.24)
Processing speed	1.06 (1.01, 1.11)*	1.11 (1.06, 1.16)‡	1.04 (0.99, 1.10)	1.07 (1.02, 1.13)†	1.07 (1.00, 1.14)	1.00 (0.96, 1.04)	0.98 (0.94, 1.03)
	1.06 (1.00, 1.12)*	1.11 (1.05, 1.17)‡	1.06 (1.00, 1.13)*	1.07 (1.00, 1.14)	1.01 (0.93, 1.10)	0.99 (0.95, 1.04)	1.02 (0.97, 1.07)

Notes:

* =p<0.05

† p<0.01

‡ p<0.001