BMJ Open

Structural and Functional Support among Older Adults with Asthma: Associations with Medication Adherence

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2018-027430
Article Type:	Research
Date Submitted by the Author:	22-Oct-2018
Complete List of Authors:	O'Conor, Rachel; Northwestern University, General Internal Medicine and Geriatrics Hebert-Beirne, Jeni; University of Illinois at Chicago, School of Public Health Morrissey Kwasny, Mary ; Northwestern University Eldeirawi, Kamal; University of Illinois at Chicago, College of Nursing Hasnain-Wynia, Romana; Denver Health and Hospital Authority Wisnivesky, Juan; Icahn School of Medicine at Mount Sinai Wolf, Michael; Northwestern University, Department of General Internal Medicine Federman, Alex; Icahn School of Medicine at Mount Sinai
Keywords:	Asthma < THORACIC MEDICINE, SOCIAL MEDICINE, GERIATRIC MEDICINE

Structural and Functional Support among Older Adults with Asthma: Associations with Medication Adherence

Rachel O'Conor PhD MPH[1], Jeni Hebert-Beirne PhD MPH[2], Mary Kwasny ScD[3], Kamal Eldeirawi PhD RN[4], Romana Hasnain-Wynia, PhD[5], Juan P Wisnivesky MD DrPH[6,7], Michael S. Wolf, PhD MPH[1], Alex D. Federman MD, MPH[6]

[1]Division of General Internal Medicine and Geriatrics, Northwestern University
[2]Division of Community Health Sciences, School of Public Health, University of Illinois at Chicago
[3]Department of Preventive Medicine, Northwestern University
[4]College of Nursing, University of Illinois at Chicago
[5]Office of Research, Denver Health and Hospital Authority
[6]Division of General Internal Medicine, Icahn School of Medicine at Mount Sinai
[7]Division of Pulmonary, Critical Care and Sleep Medicine, Icahn School of Medicine at Mount Sinai, New York City, New York

Corresponding author
Rachel O'Conor, PhD MPH
Division of General Internal Medicine
Feinberg School of Medicine
Northwestern University
750. N. Lake Shore Drive, 10th Floor
Chicago, IL 60611
Phone: (312) 503-3240
Email: r-oconor@northwestern.edu

Key Words: psychosocial factors, asthma, health behavior, geriatrics

Word Count (text): 3010
Word Count (abstract): 245

Funding: This study was supported by a grant from the National Heart, Lung, and Blood Institute (R01HL096612).

Strengths and limitations of this study

- Associations between social support and medication adherence have previously been documented; however, few studies have been conducted among older adults and populations experiencing significant adversity, who may benefit from social support as they seek to manage their medications.
- We found that the receipt of frequent functional support in managing medications was associated with poor adherence to asthma medications among socially and economically disadvantaged older adults.
- Future research is need to better understand the manner in which functional support operations in relation to medication adherence among older adults.

ABSTRACT

Objectives: Disadvantaged older adults may benefit from social support in adhering to their medications, but the multidimensional nature of social relationships makes it difficult to identify the most relevant domain. We examined associations of structural and functional support with medication adherence among a cohort of older adults with asthma.

Methods: A secondary data analysis from a cohort of older adults (≥ 60 years) with asthma. Measures of structural support (Lubben Social Network Scale), functional support (Support with Medication Management Scale), and medication adherence (dose counts from inhaler, self-report) were collected during in-person interviews. Multivariable logistic regression models tested the associations of structural and functional support with adherence to asthma medications.

Results: Among 383 participants, the mean age was 67 years, 38% identified as Hispanic, 33% identified as Black, 52% reported monthly incomes ≤$1350, and 64% demonstrated poor adherence to their asthma controller medication. Structural and functional support were weakly correlated (r = -0.15, p=0.005). In adjusted analyses, structural support was not associated with medication adherence. Participants who received infrequent functional support in managing their medications had lower odds of poor adherence according to dose counts (OR 0.51, 95% CI 0.26, 0.98), but not when assessed via self-report (OR 0.81, 95% CI 0.44, 1.48).

Conclusion: The receipt of frequent functional support in managing medications was associated with poor adherence to asthma controller medications. Further research is needed to better understand the manner and context which functional support operates in relation to medication adherence among older adults.

INTRODUCTION

Socially and economically disadvantaged older adults who are known to have low rates of medication adherence,[1-3] due to numerous barriers accessing and taking often complex regimens[4-6] may benefit from social support as they seek to manage their medications. Social relationships are commonly distinguished by the structure or function of the support provided; structural support refers to the size and extent which individuals are integrated within their social network, while functional support encompasses the specific utility provided by the relationships.[7] The multidimensional nature of social support, makes it challenging to identify the most relevant dimension related to medication-taking behaviors to act upon.[7 8] Further complicating this understanding is the paucity of literature among low-income and racially and ethnically diverse older adults related to social support and medication adherence. A recent systematic review detailing associations between medication adherence and social support only identified a few investigations among older adults, and none were among older adults facing significant adversity.[9] The review overall did not observe consistent associations among the studies that measured structural aspects, while the few studies that assessed functional support in terms of the tangible assistance that was provided did observe a consistent positive relationship with medication adherence, but these measures were variable and not always aligning with specific medication-taking behaviors that may be most beneficial to promoting medication adherence.[9]

While there is a growing recognition of the benefits functional support may provide in promoting medication adherence, no evaluation to our knowledge has compared functional versus structural support to ascertain what is more likely to facilitate medication adherence among a diverse older sample.[10 11] The Asthma Beliefs and Literacy in the Elderly (ABLE) cohort provides an opportunity to investigate this as measures of structural and functional support and medication

adherence were collected. The cohort is particularly relevant as the sample is comprised of a socioeconomically and culturally diverse older adults who were managing multiple chronic conditions, in addition to asthma, and medication adherence for asthma can be particularly challenging due to the array of asthma medications that are used under different circumstances.[12] Therefore, we sought to investigate associations between structural and functional support and medication adherence in the ABLE cohort. It was hypothesized that functional support, and not structural support, would be associated with medication adherence, and that less frequent functional support related to medication management would be associated with poorer medication adherence.

METHODS

Sample

We conducted a cross-sectional secondary data analysis with data from a National Heart Lung and Blood Institute funded study, Asthma Beliefs and Literacy in the Elderly (ABLE; R01HL096612). A full description of the cohort has previously been published.[13] Briefly, the sample was recruited from outpatient practices in New York City, New York and Chicago, Illinois from December 2009 through May 2012. Patients were eligible to participate if they: 1) were aged 60 years and older, 2) spoke English or Spanish, and 3) had moderate or severe persistent asthma.[12] Exclusion criteria included a chart-documented or self-reported diagnosis of chronic obstructive pulmonary disease (COPD) or other chronic respiratory illness or self-reported smoking history of <10 pack-years because they are at increased risk of COPD. A total of 452 participants were enrolled and provided written consent. The study was approved by the Institutional Review Boards of the Mount Sinai School of Medicine and Northwestern University.

Measures

Medication Adherence

Adherence was measured through a review of the analog dose counters on participants' inhalers over a 30-day period. Research staff reviewed the device to collect an initial reading during the baseline interview, and then contacted participants by telephone 30 days later to record the number of doses remaining. Research staff also documented whether the participant had started a new device. Research staff attached a Doser CT (MEDITRACK, MA) electronic monitoring device atop metered dose inhalers that did not have counters built into the inhalers. The Doser CT electronically recorded the number of times the device was used each day, and participants returned the electronic device to the study team by mail. Adherence was calculated by the total doses taken divided by the total doses prescribed during the 30 day period. Poor adherence was defined as 80% or less of expected doses recorded.[14 15]

Medication adherence was also collected via self-report with the Medication Adherence Reporting Scale (MARS). The MARS is a validated, 10-item measure previously adapted to assess adherence with asthma medications and is correlated with an objective electronic monitoring measure of adherence.[16] The scale examines both intentional and non-intentional aspects of medication 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 less than 4.5 are classified as having poor adherence to controller medications, which is equivalent to sometimes (or more often) forgetting to take the medication.[16]

Structural Support

Structural support was assessed by the size of an individual's social network using the abbreviated (6-item) Lubben Social Network Scale (LSNS).[17] The LSNS was developed to evaluate the number of familial and friendship ties maintained by an older adult population.[18] The LSNS poses three questions each about familial and friendship ties, including how many relatives and/or friends one sees or hears from at least monthly, feels close enough with to call on for help, and feels at ease with to talk about private matters. Scores range from 0 to 30; those with scores less than 12 are considered at risk for social isolation.[17]

Functional Support

Functional support was measured as the frequency of tangible medication social support with the Support with Medication Management Scale (SMMS). The SMMS was developed by the study team to assess the extent which participants receive tangible assistance from family, friends, or paid caregivers in managing their health and taking medicines. A new scale was developed after identifying a void in existing assessments that capture the frequency of supportive behaviors related to medication self-management. The original scale included 16 items which assessed support in a range of behaviors related to taking medication, including attending doctor visits, calling the pharmacy, picking up medication, assistance with medication organization, and reminders to take asthma and all medications. Participants are asked the frequency with which they receive assistance for each item; response are on a 5-point Likert scale.

The distribution of responses for each item in the SMMS was reviewed and any item with minimal variation (≥85% of participants responded never or rarely) was dropped; 8 items were included in the total score. We conducted a factor analysis using orthogonal rotation to confirm the scale was measuring a single latent variable, and measured Cronbach's alpha to assess

internal consistency. The eight items loaded onto one factor (Eigen: 4.37, factor loadings range 0.68 – 0.81), and α=0.90. We also conducted a confirmatory factor analysis using orthogonal rotation to assess item convergence and discrimination with other scales (ADLs, structural support), in which all items from the individual scales loaded onto their respective scales. SMMS scores were summed and we used a median split to represent the level of assistance provided (infrequent support, frequent support).

Covariates

Self-reported gender, age, race/ethnicity, monthly household income, educational attainment, and marital status were collected. A measure of asthma history (number of years since diagnosis) was also included since long-term experience with asthma could affect asthma self-management behaviors. Beliefs about asthma controller medications were assessed using the Beliefs about Medications Questionnaire (BMQ), a 10-item questionnaire that measures a patient's beliefs about drugs related to two domains: concerns and necessity.[19] Health literacy was measured using the Short Test of Functional Health Literacy in Adults (S-TOFHLA).[20] Health status was measured via self-reported number of chronic conditions and limitations in activities of daily living (ADLs) using the Katz Index of ADLs.[21] We also created a composite variable to identify individuals in poor health status; patients were classified as poor health status if they were diagnosed with five or more chronic conditions or were classified as having one or more limitation in ADLs.

Patient and public involvement

Patients and the public were not involved in the design or conduct of this research study.

Statistical Analysis

Analyses were limited to participants who were prescribed an asthma controller medication and had complete functional and structural support assessments (n=338). First, we conducted chi square and analysis of variance (ANOVA) tests to examine differences in the primary independent variables (structural support, functional support) and demographic and health status measures. Next, we conducted chi square analyses to examine the relationship between structural support, functional support and adherence to asthma controller medication (measured via dose counts and self-report). Unadjusted and adjusted logistic regression models were conducted to examine the independent associations of structural and function support and adherence to asthma controller medications. Good adherence was the referent category. In order to account for potential confounding of differences in health status we repeated the analysis stratified by the poor health status indicator. We subsequently conducted a Mantel-Haenszel test for homogeneity of odds ratio to test if the association of functional support with medication adherence was significantly different by health status. All analyses were performed using STATA 13.1 (College Station, TX).

RESULTS

The mean age of the sample was 67 (± 6.5) years. There was racial and ethnic diversity [Hispanic (38%), Black (33%), White (24%)] (Table 1), and the majority of participants were low-income, 52% reported monthly incomes ≤$1350, and female (84%). There were very low rates of medication adherence to asthma controller medication, with 36.3% reported good adherence when measured via dose counts, and 38.6% reported good adherence by self-report assessments. The agreement between the two forms of collection was 67.7% ($\kappa = 0.32$, $p<0.001$). There were no

significant differences in any demographic variables or outcomes between those who did and did not complete the adherence assessment by dose counts (p's>0.05).

The distribution of responses to the SMMS are presented in Table 2. A third of participants reported that someone accompanied them to medical appointments and brought prescription medicines to the pharmacy at least some of the time (38.1%, 33.8%, respectively). Nearly half (42%) of participants reported that someone else picked up their medicines from the pharmacy at least some of the time. Participants received less assistance in terms of reminders to take medications; most reported that no one ever reminded them to take their asthma controller (75.7%) or other (72.8%) medication. Additionally, less than a quarter received assistance at least some of the time calling the physician when medicines were running low (19.6%), calling the pharmacy for refills (23.4%), or asking a physician what a new medicine is for (16.9%).

The mean structural support score was 16.8 (SD=6.4) (range 0-30), and 21% were classified as socially isolated. Those who were socially isolated were more likely to identify as Hispanic, have lower educational attainment, household income, health literacy, one or more ADL impairment; diagnosed with more chronic conditions; and be unmarried as compared to individuals who were socially connected (p's<0.05). A weak, yet significant, negative correlation was found between the two measures of structural and functional support (r = -0.15, p=0.005), indicating that those with fewer individuals in their social network reported greater frequency of tangible medication social support. A total of 42 (12.4%) individuals who were identified as socially isolated also reported receiving frequent support with managing their medications.

Structural support was not associated with either measure of medication adherence (Table 3). However, individuals who reported infrequent functional support had lower rates of poor

medication adherence compared to those with frequent assistance managing medications (dose counts: 53.9% vs. 71.1%, p=0.002; self-report 56.7% vs. 72.7%, p=0.007).

These associations remained in multivariable adjusted analyses (Table 4) for medication adherence assessed by dose counts (OR 0.51, 95% CI 0.26, 0.98), but not by self-report (OR 0.81, 95% CI 0.44, 1.48), indicating that those with infrequent functional support have a decreased odds of non-adherence compared with their counterparts with frequent functional support. We also conducted analyses stratified by health status (Table 4); the test for homogeneity of odds ratio was non-significant (dose counts: $\chi^2 = 0.69$, p=0.41; self-report: $\chi^2 = 0.36$, p=0.57), indicating that the association between medication adherence and functional social support was not significantly different by health status.

DISCUSSION

Theoretical models of social support suggest that social support influences health outcomes through psychological and behavioral pathways.[7] Despite this proposed model, few studies have tested the pathway between social support and health behaviors in the form of adherence to medications among socioeconomically and racially/ethnically diverse older adults. Social support may be of great benefit to older adults who frequently manage complex multi-drug regimens; however, the multidimensional nature of social support challenges the identification of the most relevant domains.[7 8] As few studies have specifically targeted a more socioeconomically disadvantaged older population, we tested associations between functional and structural support with adherence to medication among this population.

In a sample of socioeconomically and culturally diverse older adults with asthma we did not observe an association between adherence to asthma controller medications and structural

support. Our findings are congruous with related literature that has not observed consistent associations between medication adherence and structural measures of support,[9] as well as broader self-management behaviors.[10 11] Not surprising, these findings suggest that the presence of individuals within older adults support network, independent of their functional contributions, may be an oversimplification of the mechanism through which social support influences health behaviors.

We hypothesized that infrequent functional support with medication management tasks would be associated with poorer medication adherence. To the contrary, we observed the inverse relationship, that receipt of more frequent functional support with medication management tasks was associated with poorer adherence to asthma controller medications. Reviewing the distribution of responses among the items within the SMMS, we observed that the greatest rates of assistance were among more intensive yet less frequent tasks, such as accompanying participants to medical appointments or picking up medications from the pharmacy. Conversely, tasks that occurred on a daily basis, such as reminders to take medicines, occurred less often. A series of sequential behaviors must occur to accurately adhere to medications, including filling and picking up a prescription, organizing and planning when to take the medication, and actually taking the correct medication dosage,[22] and older adults may require more regular assistance throughout the continuum of steps.

Our SMMS was designed to measure received functional support, and true to the multidimensional nature of social support, there are distinctions between perceived versus received support. Perceived support encompasses one's potential *access* to social support, while received support refers to one's *utilization* of support resources.[23] Previous literature specific to received functional tangible support presents similar findings and potential explanations.[7]

One explanation for this inverse relationship is that people who have previously demonstrated poor medication adherence or greater health needs require, and likely receive, more functional support. We observed associations between comorbidity and measures of disability with functional support; however in analyses stratified by health status, we did not observe significant variations in the association between functional social support and medication adherence. Additionally, our pooled analysis included measures of health status to control for potential confounding. While our cross-sectional study design prevents us from understanding the directionality of the relationship or isolate the need for functional support, similar longitudinal investigations have found even when controlling for baseline health status, receipt of tangible support was associated with higher rates of prospective mortality.[24-26] More recent investigations of a cohort study of English civil servants found that greater levels of tangible functional support was associated with poorer physical health.[27] The authors also tested the possible bidirectional relationship between social support and health, while the results overall provided support for a bidirectional relationship between physical health and social support, this relationships did not remain in within-person analyses.[27] These findings overall suggest there are other mechanisms at work in addition to prior health status.

We also observed significant associations between socioeconomic factors and functional support. An alternative explanation for our findings may be that individuals who report greater levels of received support are also more likely to experience socioeconomic stressors, which in turn mobilizes the provision of support.[23 28] Ethnographic research in poor communities has observed among family members or acquaintances a network of reciprocity and mutual obligation through which resources flow as a means to cope with significant adversity.[29-31] It is therefore possible that among our low-income sample, individuals may receive more assistance in general

due to existing practices to cope with repeated stressful circumstances. Considered with the observed negative correlation between social isolation and frequency of functional support, individuals who receive more functional support with their medications are likely relying on only a few people. Our measure did not capture who was providing this support, or the perceived adequacy of the received support, both which may impact its effectiveness, and future research should further examine these dimensions.

These findings should be recognized in the context of several limitations. First, these were cross-sectional analyses and therefore we are limited in understanding directionality of these associations, and we cannot infer causality. Second, we conducted a secondary data analysis of a cohort of urban, predominantly female, older adults with asthma and our findings may not be generalizable to younger populations, in different disease contexts, or among an older male population. In addition, our measure of functional support was not previously validated; however, we were not aware of any medication-specific functional support measures. The SMMS demonstrated high internal reliability and acceptable construct validity. Our questions related to functional and structural support were broad by design and we did not inquire about who provided the support and the patient's perceived adequacy of the received support. Lastly, our outcome measurement of medication adherence had moderate agreement between the subjective and objective measurements.

These findings are an important contribution to the literature on social support and self-management behaviors as very few studies have been conducted in elderly, non-white, or low-income samples.[10 11] Our findings underscore the complex and multidimensional nature of social support and the mechanisms in which it operates. Further research is needed to better understand

the manner in which functional support operates in relation to medication adherence among older adults.

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

Disclosure of potential conflicts of interest: Drs. O'Conor, Hebert-Beirne, Kwasny, Eldeirawi, Hasnain-Wynia and 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.

Data sharing statement: No additional data are available.

REFERENCES

1. Naderi SH, Bestwick JP, Wald DS. Adherence to drugs that prevent cardiovascular disease: meta-analysis on 376,162 patients. *Am J Med* 2012;125(9):882-87
2. Benner JS, Glynn RJ, Mogun H, et al. Long-term persistence in use of statin therapy in elderly patients. *JAMA* 2002;288(4):455-61.
3. Federman AD, Wolf MS, Sofianou A, et al. Self-management behaviors in older adults with asthma: associations with health literacy. *J Am Geriatr Soc* 2014;62(5):872-9.
4. Gellad WF, Grenard JL, Marcum ZA. A Systematic Review of Barriers to Medication Adherence in the Elderly: Looking Beyond Cost and Regimen Complexity. *Am J Geriatr Pharmacother* 2011;9(1):11-23.
5. Gellad WF, Haas JS, Safran DG. Race/Ethnicity and Nonadherence to Prescription Medications Among Seniors: Results of a National Study. *J Gen Intern Med* 2007;22(11):1572-78.
6. Insel K, Morrow D, Brewer B, et al. Executive function, working memory, and medication adherence among older adults. *J Gerontol B Psychol Sci Soc Sci* 2006;61(2):P102-P07.
7. Holt-Lunstad J, Uchino BN. Social Support and Health. In: Glanz K, Rimer BK, Viswanath K, eds. Health Behavior: Theory, Research, and Practice: John Wiley & Sons 2015:183-242.
8. National Academies of Sciences E, Medicine. Accounting for Social Risk Factors in Medicare Payment: Identifying Social Risk Factors. Washington, DC: National Academies Press 2017.
9. Scheurer D, Choudhry N, Swanton KA, et al. Association between different types of social support and medication adherence. *Am J Manag Care* 2012;18(12):e461-7.

10. Gallant MP. The Influence of Social Support on Chronic Illness Self-Management: A Review and Directions for Research. *Health Educ Behav* 2003;30(2):170-95.

11. DiMatteo MR. Social support and patient adherence to medical treatment: a meta-analysis. *Health Psychol* 2004;23(2):207.

12. Expert Panel Report 3 (EPR-3): Guidelines for the Diagnosis and Management of Asthma-Summary Report 2007. *J Allergy Clin Immunol* 2007;120(5 Suppl):S94-138.

13. O'Conor R, Wolf MS, Smith SG, et al. Health literacy, cognitive function, proper use, and adherence to inhaled asthma controller medications among older adults with asthma. *Chest* 2015;147(5):1307-15.

14. Osterberg L, Blaschke T. Adherence to medication. *N Engl J Med* 2005;353(5):487-97.

15. Williams LK, Joseph CL, Peterson EL, et al. Patients with asthma who do not fill their inhaled corticosteroids: a study of primary nonadherence. *J Allergy Clin Immunol* 2007;120(5):1153-59.

16. Cohen JL, Mann DM, Wisnivesky JP, et al. Assessing the validity of self-reported medication adherence among inner-city asthmatic adults: the Medication Adherence Report Scale for Asthma. *Ann Allergy Asthma Immunol* 2009;103(4):325-31.

17. Lubben J, Blozik E, Gillmann G, et al. Performance of an abbreviated version of the Lubben Social Network Scale among three European community-dwelling older adult populations. *Gerontologist* 2006;46(4):503-13.

18. Lubben JE. Assessing social networks among elderly populations. *Fam Community Health* 1988;11(3):42-52.

19. Horne R, Weinman J, Hankins M. The beliefs about medicines questionnaire: the development and evaluation of a new method for assessing the cognitive representation of medication. *Psychol Health* 1999;14(1):1-24.

20. Baker DW, Williams MV, Parker RM, et al. Development of a brief test to measure functional health literacy. *Patient Educ Couns* 1999;38(1):33-42.

21. Katz S, Ford A, Moskowitz R, et al. Studies of Illness in the Aged. The Index of ADL: A Standardized Measure of Biological and Psychosocial Function. *JAMA* 1963;185:914-9.

22. Bailey SC, Oramasionwu CU, Wolf MS. Rethinking adherence: a health literacy-informed model of medication self-management. *J Health Commun* 2013;18 Suppl 1:20-30.

23. Uchino BN. Understanding the links between social support and physical health: A life-span perspective with emphasis on the separability of perceived and received support. *Perspect Psychol Sci* 2009;4(3):236-55.

24. Forster LE, Stoller EP. The impact of social support on mortality: A seven-year follow-up of older men and women. *J Appl Gerontol* 1992;11(2):173-86.

25. Krause N. Received support, anticipated support, social class, and mortality. *Res Aging* 1997;19(4):387-422.

26. Kaplan GA, Wilson TW, Cohen RD, et al. Social Functioning and Overall Mortality: Prospective Evidence from the Kuopio Ischemic Heart Disease Risk Factor Study. *Epidemiology* 1994;5(5):495-500.

27. Hakulinen C, Pulkki-Råback L, Jokela M, et al. Structural and functional aspects of social support as predictors of mental and physical health trajectories: Whitehall II cohort study. *J Epidemiol Community Health* 2016;70(7):710-15.

28. Barrera M. Distinctions between social support concepts, measures, and models. *Am J Community Psychol* 1986;14(4):413-45.

29. Desmond M. Disposable Ties and the Urban Poor. *Am J Sociol* 2012;117(5):1295-335. doi: 10.1086/663574

30. Desmond M. Evicted: Poverty and profit in the American city: Broadway Books 2016.

31. Stack CB. All our kin: Strategies for survival in a black community: Basic Books 1975.

Table 1. Differences in demographic and health characteristics between functional and structural measures of social relationships

	All Participants (n=338)	Structural Support: Socially Connected (n=266)	Structural Support: Socially Isolated (n=72)	p-value	Functional Support: Infrequent Support (n=189)	Functional Support: Frequent Support (n=149)	p-value
Age, %				0.54			0.15
60-64	44.5	44.9	43.1		49.2	38.5	
65-69	24.3	25.3	20.8		22.2	27.0	
70+	31.2	29.8	36.1		28.6	34.5	
Sex, Female, %	84.0	83.8	84.7	0.86	79.4	89.9	0.008
Race, %				0.001			<0.001
Non-Hispanic Black	32.8	33.8	29.2		31.2	34.9	
Non-Hispanic White	24.0	27.8	9.7		36.5	8.1	
Hispanic	38.5	34.2	54.2		27.5	52.3	
Other	4.7	4.1	6.9		4.8	4.7	
Education, %				<0.001			<0.001
Less than high school	33.1	28.2	51.4		23.3	45.6	
High school graduate	16.9	15.4	22.2		13.2	21.5	
Some college	20.7	24.1	8.3		23.8	16.8	
College graduate	29.3	32.3	18.1		39.7	16.1	
Monthly income, %				<0.001			<0.001
≤$1,350	52.4	46.5	74.3		39.8	68.7	
$1,351 - $3,000	24.3	26.5	15.7		30.1	16.7	
≥$3,001	23.3	27.0	10.0		30.1	14.6	
Health Literacy, %				0.001			<0.001
Limited	31.4	28.7	50.0		22.8	47.1	
Adequate	68.6	71.3	50.0		77.2	52.9	
Married, %	31.1	34.2	19.4	0.02	32.3	29.5	0.59
ADL Limitation, %				0.03			<0.001
0	70.3	73.2	59.7		81.9	55.7	
≥ 1	29.7	26.8	40.3		18.1	44.3	
# Chronic Conditions, Mean (SD)	3.8 (1.6)	3.6 (1.5)	4.8 (1.6)	<0.001	3.4 (1.4)	4.4 (1.4)	<0.001
Poor Health Status, %	46.6	41.5	62.3	<0.001	30.9	66.4	<0.001

Table 2. Distribution of responses to items in the Support with Medication Management Scale assessment of functional social support

Question: How often does someone else:	%
Come with to medical appointments	
Always	19.8
Often	4.4
Sometimes	13.9
Rarely	10.4
Never	51.5
Call physician when running out of medicines	
Always	9.8
Often	2.1
Sometimes	7.7
Rarely	4.7
Never	75.7
Call pharmacy for refills	
Always	12.7
Often	2.7
Sometimes	8.0
Rarely	6.5
Never	70.1
Bring prescriptions to pharmacy to be filled	
Always	16.3
Often	4.2
Sometimes	13.3
Rarely	9.2
Never	57.1
Pick up medicines at pharmacy	
Always	19.0
Often	4.0
Sometimes	19.0
Rarely	13.6
Never	44.4
Remind to take asthma controller medicine	
Always	7.1
Often	1.5
Sometimes	8.9
Rarely	6.8
Never	75.7
Remind to take other medicines	
Always	9.6
Often	2.1
Sometimes	9.0
Rarely	6.6
Never	72.8
Ask physician what new medicines is for	
Always	9.2
Often	2.1
Sometimes	5.6
Rarely	4.4
Never	78.7

Table 3. Differences in adherence to asthma controller medications between measures of structural and functional support

Variable	All Participants (n=338)	Structural Support: Socially Connected (n=266)	Structural Support: Socially Isolated (n=72)	Structural Support: p-value	Functional Support: Infrequent Support (n=189)	Functional Support: Frequent Support (n=149)	Functional Support: p-value
Adherence via Dose Counts, %				0.21			0.002
Good adherence	36.3	38.2	29.1		46.2	28.9	
Poor adherence	63.7	61.8	70.9		53.9	71.1	
Adherence via Self Report, %				0.17			0.007
Good adherence	38.6	40.6	31.4		43.3	27.4	
Poor adherence	61.4	59.5	68.6		56.7	72.7	

Table 4. Differences in poor adherence to asthma controller medications between measures of structural and functional support

	Dose Count of Poor Medication Adherence		Self-Report of Poor Medication Adherence	
	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Structural Social Support				
Socially isolated	1.51 (0.79, 2.87)	1.80 (0.81, 3.99)	1.48 (0.85, 2.61)	0.86 (0.42, 1.77)
Socially connected				
Functional Social Support				
Pooled				
Infrequent support	0.49 (0.29, 0.82) †	0.51 (0.26, 0.98)*	0.47 (0.30, 0.75) †	0.81 (0.44, 1.48)
Frequent support				
Stratified by Health Status				
Poor Health Status				
Infrequent support	0.37 (0.15, 0.82)*	0.32 (0.11, 0.92) *	0.67 (0.32, 1.28)	1.18 (0.45, 3.10)
Frequent support				
Adequate Health Status				
Infrequent support	0.59 (0.28, 1.27)	0.47 (0.17, 1.29)	0.47 (0.23, 0.95)*	0.70 (0.29, 1.73)
Frequent support				

[a]Adjusted analyses controlling for age, race/ethnicity, income, education, health literacy, number of years with asthma, limitations in activities of daily living and number of chronic conditions, beliefs about asthma controller medications

[b]In order to further account for confounding by health status and subsequent need of functional support we stratified by poor health status (Diagnosed with 5 or more chronic conditions or reported one or more ADL impairment). Adjusted stratified analyses were adjusted for age, race/ethnicity, income, education, health literacy, number of years with asthma, beliefs about asthma controller medications

*=p<0.05; †p<0.01; ‡p<0.001

BMJ Open

Structural and Functional Support among U.S. Older Adults with Asthma: Cross-Sectional Associations with Medication Adherence

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2018-027430.R1
Article Type:	Research
Date Submitted by the Author:	12-Jun-2019
Complete List of Authors:	O'Conor, Rachel; Northwestern University, General Internal Medicine and Geriatrics Hebert-Beirne, Jeni; University of Illinois at Chicago, School of Public Health Morrissey Kwasny, Mary ; Northwestern University Eldeirawi, Kamal; University of Illinois at Chicago, College of Nursing Hasnain-Wynia, Romana; Denver Health and Hospital Authority Wisnivesky, Juan; Icahn School of Medicine at Mount Sinai Wolf, Michael; Northwestern University, Department of General Internal Medicine Federman, Alex; Icahn School of Medicine at Mount Sinai
Primary Subject Heading:	Respiratory medicine
Secondary Subject Heading:	Health services research, Geriatric medicine, Pharmacology and therapeutics
Keywords:	Asthma < THORACIC MEDICINE, SOCIAL MEDICINE, GERIATRIC MEDICINE

Structural and Functional Support among U.S. Older Adults with Asthma: Cross-Sectional Associations with Medication Adherence

Rachel O'Conor PhD MPH[1], Jeni Hebert-Beirne PhD MPH[2], Mary Kwasny ScD[3], Kamal Eldeirawi PhD RN[4], Romana Hasnain-Wynia, PhD[5], Juan P Wisnivesky MD DrPH[6,7], Michael S. Wolf, PhD MPH[1], Alex D. Federman MD, MPH[6]

[1]Division of General Internal Medicine and Geriatrics, Northwestern University
[2]Division of Community Health Sciences, School of Public Health, University of Illinois at Chicago
[3]Department of Preventive Medicine, Northwestern University
[4]College of Nursing, University of Illinois at Chicago
[5]Office of Research, Denver Health and Hospital Authority
[6]Division of General Internal Medicine, Icahn School of Medicine at Mount Sinai
[7]Division of Pulmonary, Critical Care and Sleep Medicine, Icahn School of Medicine at Mount Sinai, New York City, New York

Corresponding author
Rachel O'Conor, PhD MPH
Division of General Internal Medicine
Feinberg School of Medicine
Northwestern University
750. N. Lake Shore Drive, 10th Floor
Chicago, IL 60611
Phone: (312) 503-3240
Email: r-oconor@northwestern.edu

Key Words: psychosocial factors, asthma, health behavior, geriatrics

Word Count (text): 3010
Word Count (abstract): 236

Funding: This study was supported by a grant from the National Heart, Lung, and Blood Institute (R01HL096612).

Strengths and limitations of this study

- We examined associations between social support and medication adherence among older adults and populations experiencing social and economic hardship; our population is unique among studies examining associations between social support and health behaviors.
- We conducted a secondary data analysis of a cohort study; we are therefore limited by the included measures that were not original intent of the aims. In addition, our measure of functional support was not previously validated; however, we were not aware of any medication-specific functional support measures
- We conducted cross-sectional analyses and therefore we are limited in understanding directionality of these associations, and we cannot infer causality

ABSTRACT

Objectives: Disadvantaged older adults may benefit from social support in adhering to their medications, but the multidimensional nature of social relationships makes it difficult to identify the most relevant domain. We examined associations of structural and functional support with medication adherence among a cohort of older adults with asthma.

Design: Cross-sectional analysis of the Asthma Beliefs and Literacy in the Elderly 'ABLE' cohort study.

Setting: Outpatient clinics in New York, New York, and Chicago, Illinois, USA.

Participants: English and Spanish speaking older adults (≥ 60 years) with asthma.

Outcome Measures: Medication adherence was measured using dose counts from inhaler and self-report.

Results: Among 383 participants, the mean age was 67 years, 38% identified as Hispanic, 33% identified as Black, 52% reported monthly incomes ≤$1350, and 64% demonstrated poor adherence to their asthma controller medication. Structural and functional support were weakly correlated (r = -0.15, p=0.005). In adjusted analyses, structural support was not associated with medication adherence. Participants who received infrequent functional support in managing their medications had lower odds of poor adherence according to dose counts (OR 0.51, 95% CI 0.26, 0.98), but not when assessed via self-report (OR 0.81, 95% CI 0.44, 1.48).

Conclusion: The receipt of frequent functional support in managing medications was associated with poor adherence to asthma controller medications. Further research is needed to better understand the manner and context which functional support operates in relation to medication adherence among older adults.

INTRODUCTION

Socially and economically disadvantaged older adults who are known to have low rates of medication adherence,[1-3] due to numerous barriers accessing and taking often complex regimens[4-6] may benefit from social support as they seek to manage their medications. Social relationships are commonly distinguished by the structure or function of the support provided, and are categorized as structural or functional support. Structural support refers to the size and extent which individuals are integrated within their social network, and examples include marital status, social network size and social isolation. Conversely, functional support encompasses the specific utility provided by the relationships.[7] Functional support is further classified into four types of social support, which include: 1) emotional, expressions of caring, 2) informational, the provision of information, 3) tangible, the provision of direct material aid or other concreate assistance, and 4) belonging, having others to engage with in social activities.[7] The multidimensional nature of social support, makes it challenging to identify the most relevant dimension related to medication-taking behaviors to act upon.[7 8] Further complicating this understanding is the paucity of literature among low-income and racially and ethnically diverse older adults related to social support and medication adherence. A recent systematic review detailing associations between medication adherence and social support only identified a few investigations among older adults, and none were among older adults facing significant social and economic hardship.[9] The review overall did not observe consistent associations among the studies that measured structural aspects, while the few studies that assessed functional support in terms of the tangible assistance that was provided did observe a consistent positive relationship with medication adherence, but these measures were variable and not always aligning with specific medication-taking behaviors that may be most beneficial to promoting medication adherence.[9]

While there is a growing recognition of the benefits functional support (tangible support in particular) may provide in promoting medication adherence, no evaluation to our knowledge has compared functional versus structural support to ascertain what is more likely to facilitate medication adherence among a diverse older sample.[10 11] The Asthma Beliefs and Literacy in the Elderly (ABLE) cohort provides an opportunity to investigate this as measures of structural and functional support and medication adherence were collected. The cohort is particularly relevant as the sample is comprised of a socioeconomically and culturally diverse older adults who were managing multiple chronic conditions, in addition to asthma. Medication adherence for asthma can be particularly challenging as individuals often use multiple inhalers which requires the deployment of multiple steps and coordinated actions, compared to the simpler task of taking tablets or capsules[12], and must also discern which inhaler to use under different circumstances (controller medicines are prescribed daily to reduce inflammation in the lungs, while rescue medicines are prescribed to be taken on an as needed basis).[12] Therefore, we sought to investigate associations between structural and functional support and medication adherence in the ABLE cohort. It was hypothesized that functional support, and not structural support, would be associated with medication adherence, and that less frequent functional support related to medication management would be associated with poorer medication adherence.

METHODS

Sample

We conducted a cross-sectional secondary data analysis with data from a National Heart Lung and Blood Institute funded study, Asthma Beliefs and Literacy in the Elderly (ABLE; R01HL096612). A full description of the cohort has previously been published.[13] Briefly, the

sample was recruited from outpatient practices in New York City, New York and Chicago, Illinois from December 2009 through May 2012. Potential participants were identified through queries of clinic records and contacted via telephone by trained research coordinators to assess eligibility. Interested and eligible participants were scheduled for an in-person baseline interview. Patients were eligible to participate if they: 1) were aged 60 years and older, 2) spoke English or Spanish, and 3) had moderate or severe persistent asthma.[12] Exclusion criteria included a chart-documented or self-reported diagnosis of chronic obstructive pulmonary disease (COPD) or other chronic respiratory illness or self-reported smoking history of ≥10 pack-years because they are at increased risk of COPD. We identified a total of 1,972 patients; successfully contact 1,506; and screened 1,025, of whom 502 were eligible. Of these, 452 participants were enrolled and provided written consent. The study was approved by the Institutional Review Boards of the Mount Sinai School of Medicine and Northwestern University.

Measures

Medication Adherence

Adherence was measured through a review of the analog dose counters on participants' inhalers over a 30-day period. Research staff reviewed the device to collect an initial reading during the baseline interview, and then contacted participants by telephone 30 days later to record the number of doses remaining. Research staff also documented whether the participant had started a new device. Research staff attached a Doser CT (MEDITRACK, MA) electronic monitoring device atop metered dose inhalers that did not have counters built into the inhalers. The Doser CT electronically recorded the number of times the device was used each day, and participants returned the electronic device to the study team by mail. Adherence was calculated by the total doses taken divided by the total doses prescribed during the 30 day period, and

participants were classified as poor or adequate adherence. Poor adherence was defined as 80% or less of expected doses recorded, following a commonly applied threshold.[14 15]

Medication adherence was also collected via self-report with the Medication Adherence Reporting Scale for Asthma (MARS-A). The MARS-A is a validated, 10-item measure previously adapted to assess adherence with asthma medications and is correlated with an objective electronic monitoring measure of adherence.[16] The scale examines both intentional and non-intentional aspects of medication 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-A score of less than 4.5 are classified as having poor adherence to daily asthma controller medications, which is equivalent to sometimes (or more often) forgetting to take the medication.[16]

Structural Support

Structural support was assessed by the size of an individual's social network using the abbreviated (6-item) Lubben Social Network Scale (LSNS).[17] The LSNS was developed to evaluate the number of familial and friendship ties maintained by an older adult population.[18] The LSNS poses three questions each about familial and friendship ties, including how many relatives and/or friends one sees or hears from at least monthly, feels close enough with to call on for help, and feels at ease with to talk about private matters. Scores range from 0 to 30; and participants were classified as socially connected (score $\geq$ 12) or socially isolated (score <12) following scoring guidance.[17]

Functional Support

Functional support was measured as the frequency of tangible medication social support with the Support with Medication Management Scale (SMMS). The SMMS was developed by the study team to assess the extent which participants receive tangible assistance from family, friends, or paid caregivers in managing their health and taking medicines. A new scale was developed after identifying a void in existing assessments that capture the frequency of supportive behaviors related to medication self-management. The item development was informed by the Medication Self-Management model which proposes a series of cyclical tasks associated with taking prescription medications; to gain the therapeutic benefits of the medication individuals must 1) fill prescriptions in a timely manner, 2) understand medication instructions, 3) organize and consolidate their regimen to the most efficient, safe daily schedule, 4) take each medication as prescribed, 5) monitor medication use and report any side effects or concerns to their provider, 6) sustain use over time.[19] The study team, which included experts in primary care, medication safety and management and health services research generated possible items and refined each question through a series of discussions.

The original scale included 16 items which assessed received support in a range of behaviors related to taking medication, including attending doctor visits, calling the pharmacy, picking up medication, assistance with medication organization, and reminders to take asthma and all medications (Supplemental Table 1). Participants are asked the frequency with which they receive assistance for each item; response are on a 5-point Likert scale.

The distribution of responses for each item in the SMMS was reviewed and any item with minimal variation (≥85% of participants responded never or rarely) was dropped; 8 items were included in the total score. We conducted a factor analysis using orthogonal rotation to confirm the scale was measuring a single latent variable, and measured Cronbach's alpha to assess

internal consistency. The eight items loaded onto one factor (Eigen: 4.37, factor loadings range 0.68 – 0.81), and α=0.90. We also conducted a confirmatory factor analysis using orthogonal rotation to assess item convergence and discrimination with other scales (ADLs, structural support), in which all items from the individual scales loaded onto their respective scales. SMMS scores were summed and we used a median split to dichotomize the level of assistance provided (infrequent support, frequent support).

Covariates

Self-reported gender, age, race/ethnicity, monthly household income, educational attainment, and marital status were collected. A measure of asthma history (number of years since diagnosis) was also included since long-term experience with asthma could affect asthma self-management behaviors. Beliefs about asthma controller medications were assessed using the Beliefs about Medications Questionnaire (BMQ), a 10-item questionnaire that measures a patient's beliefs about drugs related to two domains: concerns and necessity.[20] Health literacy was measured using the Short Test of Functional Health Literacy in Adults (S-TOFHLA).[21] Health status was measured via self-reported number of chronic conditions and limitations in activities of daily living (ADLs) using the Katz Index of ADLs.[22] In order to account for the potential confounding effect of health status and in recognition that both chronic conditions and physical function are important determinants of health status,[23] we created a composite variable to identify individuals in poor health status; patients were classified as poor health status if they were diagnosed with five or more chronic conditions or were classified as having one or more limitation in ADLs.

Patient and public involvement

Patients and the public were not involved in the design or conduct of this research study.

Statistical Analysis

The sample size for the ABLE cohort was based on the primary outcomes of the main analysis.[3 24] Analyses were limited to participants who were prescribed an asthma controller medication and had complete functional and structural support assessments (n=338). Participants who were not prescribed an asthma controller medication or incomplete functional and structural support assessments were more likely to have limited health literacy, and be low income ($p<0.05$); no other differences in demographic characteristics were observed.

First, we conducted chi-square and t-tests to examine differences in the primary independent variables (structural support, functional support) and demographic and health status measures. Next, we conducted chi square analyses to examine the relationship between structural support, functional support and adherence to asthma controller medication (measured via dose counts and self-report). Unadjusted and adjusted logistic regression models were conducted to examine the independent associations of structural and function support and adherence to asthma controller medications. Good adherence was the referent category. In order to account for potential confounding of differences in health status we repeated the analysis stratified by the poor health status indicator. We subsequently conducted a Mantel-Haenszel test for homogeneity of odds ratio to test if the association of functional support with medication adherence was significantly different by health status. Structural and functional support were dichotomized to ease interpretation, as a one-unit change on these scales is uninterpretable. As dichotomizing can lead to loss of information, and other problems,[25] a sensitivity analysis was run to examine the relationship between continuous versions of these variables and adherence. Model parameter estimates are presented in Supplemental Table 2, and similar trends were observed. All analyses were performed using STATA 13.1 (College Station, TX).

RESULTS

The mean age of the sample was 67 (± 6.5) years. There was racial and ethnic diversity [Hispanic (38%), Black (33%), White (24%)] (Table 1), and the majority of participants were low-income, 52% reported monthly incomes ≤$1350, and female (84%). There were very low rates of medication adherence to asthma controller medication, with 36.3% reported good adherence when measured via dose counts, and 38.6% reported good adherence by self-report assessments. The agreement between the two forms of collection was 67.7% ($\kappa = 0.32$, $p<0.001$). There were no significant differences in any demographic variables or outcomes between those who did and did not complete the adherence assessment by dose counts (p's>0.05).

The distribution of responses to the SMMS are presented in Table 2. A third of participants reported that someone accompanied them to medical appointments and brought prescription medicines to the pharmacy at least some of the time (38.1%, 33.8%, respectively). Nearly half (42%) of participants reported that someone else picked up their medicines from the pharmacy at least some of the time. Participants received less assistance in terms of reminders to take medications; most reported that no one ever reminded them to take their asthma controller (75.7%) or other (72.8%) medication. Additionally, less than a quarter received assistance at least some of the time calling the physician when medicines were running low (19.6%), calling the pharmacy for refills (23.4%), or asking a physician what a new medicine is for (16.9%).

The mean structural support score was 16.8 (SD=6.4) (range 0-30), and 21% were classified as socially isolated. Those who were socially isolated were more likely to identify as Hispanic, have lower educational attainment, household income, health literacy, one or more ADL

impairment; diagnosed with more chronic conditions; and be unmarried as compared to individuals who were socially connected (p's<0.05). A weak, yet significant, negative correlation was found between the two measures of structural and functional support (r = -0.15, p=0.005), indicating that those with fewer individuals in their social network reported greater frequency of tangible medication social support. Among the entire sample, a total of 42 (12.4%) individuals who were identified as socially isolated also reported receiving frequent support with managing their medications.

Structural support was not associated with either measure of medication adherence (Table 3). However, individuals who reported infrequent functional support had lower rates of poor medication adherence compared to those with frequent assistance managing medications (dose counts: 53.9% vs. 71.1%, p=0.002; self-report 56.7% vs. 72.7%, p=0.007).

These associations remained in multivariable adjusted analyses (Table 4) for medication adherence assessed by dose counts (OR 0.51, 95% CI 0.26, 0.98), but not by self-report (OR 0.81, 95% CI 0.44, 1.48), indicating that those with infrequent functional support have a decreased odds of non-adherence compared with their counterparts with frequent functional support. We also conducted analyses stratified by health status (Table 4); the test for homogeneity of odds ratio was non-significant (dose counts: $\chi^2 = 0.69$, p=0.41; self-report: $\chi^2 = 0.36$, p=0.57), indicating that the association between medication adherence and functional social support was not significantly different by health status.

DISCUSSION

Theoretical models of social support suggest that social support influences health outcomes through psychological and behavioral pathways.[7] Despite this proposed model, few studies have

tested the pathway between social support and health behaviors in the form of adherence to medications among socioeconomically and racially/ethnically diverse older adults. Social support may be of great benefit to older adults who frequently manage complex multi-drug regimens; however, the multidimensional nature of social support challenges the identification of the most relevant domains.[7] [8] As few studies have specifically targeted a more socioeconomically disadvantaged older population, we tested associations between functional and structural support with adherence to medication among this population.

In a sample of socioeconomically and culturally diverse older adults with asthma we did not observe an association between adherence to asthma controller medications and structural support. Our findings are congruous with related literature that has not observed consistent associations between medication adherence and structural measures of support,[9] as well as broader self-management behaviors.[10] [11] Not surprising, these findings suggest that the presence of individuals within older adults support network, independent of their functional contributions, may be an oversimplification of the mechanism through which social support influences health behaviors.

We hypothesized that infrequent functional support with medication management tasks would be associated with poorer medication adherence. To the contrary, we observed the inverse relationship, that receipt of more frequent functional support with medication management tasks was associated with poorer adherence to asthma controller medications. Reviewing the distribution of responses among the items within the SMMS, we observed that the greatest rates of assistance were among more intensive yet less frequent tasks, such as accompanying participants to medical appointments or picking up medications from the pharmacy. Conversely, tasks that occurred on a daily basis, such as reminders to take medicines, occurred less often. A

series of sequential behaviors must occur to accurately adhere to medications, including filling and picking up a prescription, organizing and planning when to take the medication, and actually taking the correct medication dosage,[19] and older adults may require more regular assistance throughout the continuum of steps.

Our SMMS was designed to measure received functional support, and true to the multidimensional nature of social support, there are distinctions between perceived versus received support. Perceived support encompasses one's potential *access* to social support, while received support refers to one's *utilization* of support resources.[26] Previous literature specific to received functional tangible support presents similar findings and potential explanations.[7]

One explanation for this inverse relationship is that people who have previously demonstrated poor medication adherence or greater health needs require, and likely receive, more functional support. We observed associations between comorbidity and measures of disability with functional support; however in analyses stratified by health status, we did not observe significant variations in the association between functional social support and medication adherence. Additionally, our pooled analysis included measures of health status to control for potential confounding. While our cross-sectional study design prevents us from understanding the directionality of the relationship or isolate the need for functional support, similar longitudinal investigations have found even when controlling for baseline health status, receipt of tangible support was associated with higher rates of prospective mortality.[27-29] More recent investigations of a cohort study of English civil servants found that greater levels of tangible functional support was associated with poorer physical health.[30] The authors also tested the possible bidirectional relationship between social support and health, while the results overall provided support for a bidirectional relationship between physical health and social support, this relationships did not

remain in within-person analyses.[30] These findings overall suggest there are other mechanisms at work in addition to prior health status.

We also observed significant associations between socioeconomic factors and functional support. An alternative explanation for our findings may be that individuals who report greater levels of received support are also more likely to experience socioeconomic stressors, which in turn mobilizes the provision of support.[26 31] Ethnographic research in poor communities has observed among family members or acquaintances a network of reciprocity and mutual obligation through which resources flow as a means to cope with significant adversity.[32-34] It is therefore possible that among our low-income sample, individuals may receive more assistance in general due to existing practices to cope with repeated stressful circumstances. Considered with the observed negative correlation between social isolation and frequency of functional support, individuals who receive more functional support with their medications are likely relying on only a few people. Our measure did not capture who was providing this support, or the perceived adequacy of the received support, both which may impact its effectiveness, and future research should further examine these dimensions.

These findings should be recognized in the context of several limitations. First, these were cross-sectional analyses and therefore we are limited in understanding directionality of these associations, and we cannot infer causality. Second, we conducted a secondary data analysis of a cohort of urban, predominantly female, older adults with asthma and our findings may not be generalizable to younger populations, in different disease contexts, or among an older male population. In addition, our measure of functional support was not previously validated; however, we were not aware of any medication-specific functional support measures. The SMMS demonstrated high internal reliability and acceptable construct validity. As this was a new measure

we utilized a median split to dichotomize some variables, and a clinically meaningful cut-off may provide additional utility. Our questions related to functional and structural support were broad by design and we did not inquire about who provided the support and the patient's perceived adequacy of the received support. Additionally, our outcome measurement of medication adherence had moderate agreement between the subjective and objective measurements. Lastly, to facilitate interpretation of our findings we dichotomized functional and structural support. We ran sensitivity analyses to examine the relationship between continuous versions of the variables and adherence. The trends of lower support being associated with poorer adherence was consistent, with the only exception being the adjusted model of functional support on dose count of poor adherence, in which we saw a similar trend, but it failed to reach statistical significance (p=0.06).

These findings are an important contribution to the literature on social support and self-management behaviors as very few studies have been conducted in elderly, non-white, or low-income samples.[10] Our findings underscore the complex and multidimensional nature of social support and the mechanisms in which it operates. Further research is needed to better understand the manner in which functional support operates in relation to medication adherence among older adults.

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

Disclosure of potential conflicts of interest: Drs. O'Conor, Hebert-Beirne, Kwasny, Eldeirawi, Hasnain-Wynia and 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.

Data sharing statement: No additional data are available.

REFERENCES

1. Naderi SH, Bestwick JP, Wald DS. Adherence to drugs that prevent cardiovascular disease: meta-analysis on 376,162 patients. *Am J Med* 2012;125(9):882-87

2. Benner JS, Glynn RJ, Mogun H, et al. Long-term persistence in use of statin therapy in elderly patients. *JAMA* 2002;288(4):455-61.

3. Federman AD, Wolf MS, Sofianou A, et al. Self-management behaviors in older adults with asthma: associations with health literacy. *J Am Geriatr Soc* 2014;62(5):872-9.

4. Gellad WF, Grenard JL, Marcum ZA. A Systematic Review of Barriers to Medication Adherence in the Elderly: Looking Beyond Cost and Regimen Complexity. *Am J Geriatr Pharmacother* 2011;9(1):11-23.

5. Gellad WF, Haas JS, Safran DG. Race/Ethnicity and Nonadherence to Prescription Medications Among Seniors: Results of a National Study. *J Gen Intern Med* 2007;22(11):1572-78.

6. Insel K, Morrow D, Brewer B, et al. Executive function, working memory, and medication adherence among older adults. *J Gerontol B Psychol Sci Soc Sci* 2006;61(2):P102-P07.

7. Holt-Lunstad J, Uchino BN. Social Support and Health. In: Glanz K, Rimer BK, Viswanath K, eds. Health Behavior: Theory, Research, and Practice: John Wiley & Sons 2015:183-242.

8. National Academies of Sciences E, Medicine. Accounting for Social Risk Factors in Medicare Payment: Identifying Social Risk Factors. Washington, DC: National Academies Press 2017.

9. Scheurer D, Choudhry N, Swanton KA, et al. Association between different types of social support and medication adherence. *Am J Manag Care* 2012;18(12):e461-7.

10. Gallant MP. The Influence of Social Support on Chronic Illness Self-Management: A Review and Directions for Research. *Health Educ Behav* 2003;30(2):170-95.

11. DiMatteo MR. Social support and patient adherence to medical treatment: a meta-analysis. *Health Psychol* 2004;23(2):207.

12. George J, Phun YT, Bailey MJ, et al. Development and validation of the medication regimen complexity index. *Ann Pharmacother* 2004;38(9):1369-76.

13. O'Conor R, Wolf MS, Smith SG, et al. Health literacy, cognitive function, proper use, and adherence to inhaled asthma controller medications among older adults with asthma. *Chest* 2015;147(5):1307-15.

14. Osterberg L, Blaschke T. Adherence to medication. *N Engl J Med* 2005;353(5):487-97.

15. Williams LK, Joseph CL, Peterson EL, et al. Patients with asthma who do not fill their inhaled corticosteroids: a study of primary nonadherence. *J Allergy Clin Immunol* 2007;120(5):1153-59.

16. Cohen JL, Mann DM, Wisnivesky JP, et al. Assessing the validity of self-reported medication adherence among inner-city asthmatic adults: the Medication Adherence Report Scale for Asthma. *Ann Allergy Asthma Immunol* 2009;103(4):325-31.

17. Lubben J, Blozik E, Gillmann G, et al. Performance of an abbreviated version of the Lubben Social Network Scale among three European community-dwelling older adult populations. *Gerontologist* 2006;46(4):503-13.

18. Lubben JE. Assessing social networks among elderly populations. *Fam Community Health* 1988;11(3):42-52.

19. Bailey SC, Oramasionwu CU, Wolf MS. Rethinking adherence: a health literacy-informed model of medication self-management. *J Health Commun* 2013;18 Suppl 1:20-30.

20. Horne R, Weinman J, Hankins M. The beliefs about medicines questionnaire: the development and evaluation of a new method for assessing the cognitive representation of medication. *Psychol Health* 1999;14(1):1-24.

21. Baker DW, Williams MV, Parker RM, et al. Development of a brief test to measure functional health literacy. *Patient Educ Couns* 1999;38(1):33-42.

22. Katz S, Ford A, Moskowitz R, et al. Studies of Illness in the Aged. The Index of ADL: A Standardized Measure of Biological and Psychosocial Function. *JAMA* 1963;185:914-9.

23. McDowell I. Measuring health: a guide to rating scales and questionnaires: Oxford University Press, USA 2006.

24. Soones TN, Lin JL, Wolf MS, et al. Pathways linking health literacy, health beliefs, and cognition to medication adherence in older adults with asthma. *J Allergy Clin Immunol* 2017;139(3):804-09.

25. Altman DG, Royston P. The cost of dichotomising continuous variables. *BMJ* 2006;332(7549):1080.

26. Uchino BN. Understanding the links between social support and physical health: A life-span perspective with emphasis on the separability of perceived and received support. *Perspect Psychol Sci* 2009;4(3):236-55.

27. Forster LE, Stoller EP. The impact of social support on mortality: A seven-year follow-up of older men and women. *J Appl Gerontol* 1992;11(2):173-86.

28. Krause N. Received support, anticipated support, social class, and mortality. *Res Aging* 1997;19(4):387-422.

29. Kaplan GA, Wilson TW, Cohen RD, et al. Social Functioning and Overall Mortality: Prospective Evidence from the Kuopio Ischemic Heart Disease Risk Factor Study. *Epidemiology* 1994;5(5):495-500.

30. Hakulinen C, Pulkki-Råback L, Jokela M, et al. Structural and functional aspects of social support as predictors of mental and physical health trajectories: Whitehall II cohort study. *J Epidemiol Community Health* 2016;70(7):710-15.

31. Barrera M. Distinctions between social support concepts, measures, and models. *Am J Community Psychol* 1986;14(4):413-45.

32. Desmond M. Disposable Ties and the Urban Poor. *Am J Sociol* 2012;117(5):1295-335. doi: 10.1086/663574

33. Desmond M. Evicted: Poverty and profit in the American city: Broadway Books 2016.

34. Stack CB. All our kin: Strategies for survival in a black community: Basic Books 1975.

Table 1. Differences in demographic and health characteristics between functional and structural measures of social relationships

	All Participants (n=338)	Structural Support: Socially Connected (n=266)	Structural Support: Socially Isolated (n=72)	p-value	Functional Support: Infrequent Support (n=189)	Functional Support: Frequent Support (n=149)	p-value
Age, n (%)				0.54			0.15
60-64	150 (44.5)	119 (44.9)	31 (43.1)		93 (49.2)	57 (38.5)	
65-69	82 (24.3)	67 (25.3)	15 (20.8)		42 (22.2)	40 (27.0)	
70+	105 (31.2)	79 (29.8)	26 (36.1)		54 (28.6)	51 (34.5)	
Sex, Female, n (%)	284 (84.0)	223 (83.8)	61 (84.7)	0.86	150 (79.4)	134 (89.9)	0.008
Race, %				0.001			<0.001
Non-Hispanic Black	111 (32.8)	90 (33.8)	21 (29.2)		59 (31.2)	52 (34.9)	
Non-Hispanic White	81 (24.0)	74 (27.8)	7 (9.7)		69 (36.5)	12 (8.1)	
Hispanic	130 (38.5)	91 (34.2)	39 (54.2)		52 (27.5)	78 (52.3)	
Other	16 (4.7)	11 (4.1)	5 (6.9)		9 (4.8)	7 (4.7)	
Education, n (%)				<0.001			<0.001
Less than high school	112 (33.1)	75 (28.2)	37 (51. 4)		44 (23.3)	68 (45.6)	
High school graduate	57 (16.9)	41 (15.4)	16 (22.2)		25 (13.2)	32 (21.5)	
Some college	70 (20.7)	64 (24.1)	6 (8.3)		45 (23.8)	25 (16.8)	
College graduate	99 (29.3)	86 (32.3)	13 (18.1)		75 (39.7)	24 (16.1)	
Monthly income, n (%)				<0.001			<0.001
≤$1,350	173 (52.4)	121 (46.5)	52 (74.3)		74 (39.8)	99 (68.7)	
$1,351 - $3,000	80 (24.3)	69 (26.5)	11 (15.7)		56 (30.1)	24 (16.7)	
≥$3,001	77 (23.3)	70 (27.0)	7 (10.0)		56 (30.1)	21(14.6)	
Health Literacy, n (%)				0.001			<0.001
Limited	108 (31.4)	75 (28.7)	33 (50.0)		43 (22.8)	65 (47.1)	
Adequate	219 (68.6)	186 (71.3)	33 (50.0)		146 (77.2)	73 (52.9)	
Married, n (%)	105 (31.1)	91 (34.2)	14 (19.4)	0.02	61 (32.3)	44 (29.5)	0.59
ADL Limitation, n (%)				0.03			<0.001
0	237 (70.3)	194 (73.2)	43 (59.7)		154 (81.9)	83 (55.7)	
≥ 1	100 (29.7)	71 (26.8)	29 (40.3)		34 (18.1)	66 (44.3)	
# Chronic Conditions, Mean (SD)	3.8 (1.6)	3.6 (1.5)	4.8 (1.6)	<0.001	3.4 (1.4)	4.4 (1.4)	<0.001
Poor Health Status, n (%)	180 (46.6)	110 (41.5)	47 (62.3)	<0.001	58 (30.9)	99 (66.4)	<0.001
BMQ: Necessity, Mean (SD)	12.9 (4.6)	13.0 (4.5)	12.7 (4.4)	0.66	13.2 (4.7)	12.5 (4.2)	0.24
BMQ: Concerns, Mean (SD)	16.1 (4.4)	16.6 (4.2)	16.0 (4.6)	0.25	17.3 (4.2)	15.5 (4.2)	<0.001

Table 2. Distribution of responses to items in the Support with Medication Management Scale assessment of functional social support

Question: How often does someone else:	n (%)
Come with to medical appointments	
Always	67 (19.8)
Often	15 (4.4)
Sometimes	47 (13.9)
Rarely	35 (10.4)
Never	174 (51.5)
Call physician when running out of medicines	
Always	33 (9.8)
Often	7 (2.1)
Sometimes	26 (7.7)
Rarely	16 (4.7)
Never	256 (75.7)
Call pharmacy for refills	
Always	43 (12.7)
Often	9 (2.7)
Sometimes	27 (8.0)
Rarely	22 (6.5)
Never	237 (70.1)
Bring prescriptions to pharmacy to be filled	
Always	55 (16.3)
Often	14 (4.2)
Sometimes	45 (13.3)
Rarely	31 (9.2)
Never	193 (57.1)
Pick up medicines at pharmacy	
Always	63 (19.0)
Often	13 (4.0)
Sometimes	63 (19.0)
Rarely	45 (13.6)
Never	147 (44.4)
Remind to take asthma controller medicine	
Always	24 (7.1)
Often	5 (1.5)
Sometimes	30 (8.9)
Rarely	23 (6.8)
Never	256 (75.7)
Remind to take other medicines	
Always	32 (9.6)
Often	7 (2.1)
Sometimes	30 (9.0)
Rarely	22 (6.6)
Never	244 (72.8)
Ask physician what new medicines is for	
Always	31 (9.2)
Often	7 (2.1)
Sometimes	19 (5.6)
Rarely	15 (4.4)
Never	266 (78.7)

Table 3. Differences in adherence to asthma controller medications between measures of structural and functional support

Variable	All Participants (n=338)	Structural Support: Socially Connected (n=266)	Structural Support: Socially Isolated (n=72)	p-value	Functional Support: Infrequent Support (n=189)	Functional Support: Frequent Support (n=149)	p-value
Adherence via Dose Counts, n (%)				0.21			0.002
Good adherence	97 (36.3)	81 (38.2)	16 (29.1)		84 (46.2)	41 (28.9)	
Poor adherence	170 (63.7)	131 (61.8)	39 (70.9)		98 (53.9)	101 (71.1)	
Adherence via Self Report, n (%)				0.17			0.007
Good adherence	125 (38.6)	103 (40.6)	22 (31.4)		65 (43.3)	32 (27.4)	
Poor adherence	199 (61.4)	151 (59.5)	48 (68.6)		85 (56.7)	85 (72.7)	

Table 4. Differences in poor adherence to asthma controller medications between measures of structural and functional support

	Dose Count of Poor Medication Adherence		Self-Report of Poor Medication Adherence	
	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Structural Social Support				
Socially isolated	1.51 (0.79, 2.87)	1.80 (0.81, 3.99)	1.48 (0.85, 2.61)	0.86 (0.42, 1.77)
Socially connected				
Functional Social Support				
Pooled				
Infrequent support	0.49 (0.29, 0.82) †	0.51 (0.26, 0.98)*	0.47 (0.30, 0.75) †	0.81 (0.44, 1.48)
Frequent support				
Stratified by Health Status				
Poor Health Status				
Infrequent support	0.37 (0.15, 0.82)*	0.32 (0.11, 0.92) *	0.67 (0.32, 1.28)	1.18 (0.45, 3.10)
Frequent support				
Adequate Health Status				
Infrequent support	0.59 (0.28, 1.27)	0.47 (0.17, 1.29)	0.47 (0.23, 0.95)*	0.70 (0.29, 1.73)
Frequent support				

[a]Adjusted analyses controlling for age, race/ethnicity, income, education, health literacy, number of years with asthma, limitations in activities of daily living and number of chronic conditions, beliefs about asthma controller medications

[b]In order to further account for confounding by health status and subsequent need of functional support we stratified by poor health status (Diagnosed with 5 or more chronic conditions or reported one or more ADL impairment). Adjusted stratified analyses were adjusted for age, race/ethnicity, income, education, health literacy, number of years with asthma, beliefs about asthma controller medications

*=p<0.05; †p<0.01; ‡p<0.001

Supplemental Table 1. Original Support with Medication Management Questions
How often does someone:
1. Come with you to your doctor's appointments?*
2. Call the doctor's office when your medicines are running out?*
3. Call the pharmacy for refills of your medicines?*
4. Bring your prescriptions to the pharmacy to be filled?*
5. Pick up your medicines at the pharmacy?*
6. Pay for your medicines with their own money?
7. Put your pills in a pill organizer or pill box?
8. Put your medicines in a place where you will remember to take them?
9. Remind you to take your asthma controller medicine?*
10. Remind you to take your other medicines?*
11. Bring your medicines to you when it's time to take them?
12. Put the pills in your hand when it's time to take them?
13. Set up your nebulizer when you need to use it?
14. Ask your doctor what a new medicine is for?*
15. Ask your doctor when to take the new medicine?
16. Ask your doctor what side effects the new medicine may cause?
*Questions included in analyses

Supplemental Table 2. Differences in poor adherence to asthma controller medications between measures of structural and functional support

	Dose Count of Poor Medication Adherence		Self-Report of Poor Medication Adherence	
	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Structural Social Support	1.01 (0.97, 1.05)	1.02 (0.97, 1.07)	1.03 (1.00, 1.07)	0.99 (0.94, 1.03)
Functional Social Support				
Pooled	0.96 (0.93, 0.99) †	0.95 (0.91, 1.00)	0.95 (0.92, 0.98) †	0.98 (0.94, 1.03)
Stratified by Health Status				
Poor Health Status	0.94 (0.90, 0.99) †	0.93 (0.87, 0.99) *	0.98 (0.94, 1.02)	1.01 (0.96, 1.07)
Adequate Health Status	0.97 (0.91, 1.03)	0.95 (0.87, 1.04)	0.90 (0.83, 0.97) †	0.94 (0.85, 1.03)

[a]Adjusted analyses controlling for age, race/ethnicity, income, education, health literacy, number of years with asthma, limitations in activities of daily living and number of chronic conditions, beliefs about asthma controller medications

[b]In order to further account for confounding by health status and subsequent need of functional support we stratified by poor health status (Diagnosed with 5 or more chronic conditions or reported one or more ADL impairment). Adjusted stratified analyses were adjusted for age, race/ethnicity, income, education, health literacy, number of years with asthma, beliefs about asthma controller medications

*=p<0.05; †p<0.01; ‡p<0.001

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*
Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1, 3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any pre-specified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls ***Cross-sectional study***—Give the eligibility criteria, and the sources and methods of selection of participants	5-6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-9
Bias	9	Describe any efforts to address potential sources of bias	N/A
Study size	10	Explain how the study size was arrived at	10
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10
		(*b*) Describe any methods used to examine subgroups and interactions	10
		(*c*) Explain how missing data were addressed	N/A
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	N/A

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	10
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	6
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11, 22
		(b) Indicate number of participants with missing data for each variable of interest	22-24
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	11
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12, 25
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10, 25, supplemental table 2
Discussion			
Key results	18	Summarise key results with reference to study objectives	13-14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15-16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	15-16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	1

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.