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Effects of the Chronic Disease Self-Management Program on medication adherence among older adults

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Abstract
Despite many interventions to promote medication adherence in older adults, we know little about how medication adherence has improved as a result of such interventions. The purpose of this study was to examine the long-term program impacts on medication adherence from participating in the Chronic Disease Self-Management Program (CDSMP). Secondary data used for this study included the CDSMP participants' sociodemographic characteristics and their baseline and 6- and 12-month follow-up assessments on health-related indicators, including medication adherence, self-rated health, depression, and patient communication skills. This study included those who were 65 years or older, had one or more chronic conditions, and attended at least the first or second session. Linear mixed models were used to analyze the impacts of short-term (6 months) changes in health-related indicators on long-term (12 months) changes in medication non-adherence. The subset analyses were performed among participants with self-rated major depression at baseline. This study included 687 participants. Self-reported medication adherence did not improve significantly at 6-month follow-up assessment but significantly improved at 12-month follow-up assessment. Among those with self-reported major depression at baseline assessment, the short-term improvements in depression and self-rated health were associated with long-term changes in medication adherence. The long-term impacts of the CDSMP on medication adherence were influenced by the short-term program impacts on health-related indicators. More targeted interventions are needed for patients with major depression, and programs such as the CDSMP can be particularly helpful among the population.

INTRODUCTION

Medication use in older adults accounts for almost one third of all medication prescribed in the USA [1]. With the growth of the older adult population, the use of prescription medication and associated costs are expected to rise substantially in the future. Based on a recent national report, the use of one or more prescription drugs among older adults had increased from 74% in 1988–1994 to 90% in 2009–2012 [2], and the use of five or more prescription drugs among older adults had increased from 14% in 1998–1994 to 39% in 2009–2012 [2]. In 2015, the USA spent an estimated $457 billion on prescription medications, accounting for about 17% of the total U.S. health care costs [3]. The rise in expenditure on prescription medication is projected to exceed the growth in total health care expenditure [3]. Of special concern are the high rates of medication non-adherence in the older population (e.g., about 40% being non-adherent based on the centers for Medicare and Medicaid data) [4]. Poor medication adherence is associated

with treatment ineffectiveness, poorer clinical outcomes, and increased health care costs [5–8].

Based on a comprehensive review of the existing research about interventions for supporting medication adherence, complex interventions with multiple components had a greater likelihood of improving medication adherence for long-term conditions [9,10]. However, even the most successful intervention was not very effective [9, 10]. The review included 17 studies that had a low risk of bias [9], and only 6 showed some improvements in adherence [9]. Furthermore, even fewer studies showed improvements in clinical outcomes and observed changes were relatively small [9]. Also, the complexity of interventions decreases the likelihood of successful translation of the interventions. The diversity and complexity of interventions make it difficult to identify the essential components of the interventions that are key to the program successes. In addition, there has been a limited understanding about how each intervention component contributes in improving medication adherence. Filling these knowledge gaps is an essential step to design sustainable interventions to promote medical adherence in older adults.

This study was designed to expand the knowledge base by delving deeper and examining an intervention, Chronic Disease Self-Management Program (CDSMP), that has already been shown to be successful in improving medication adherence. The CDSMP is a general self-management program that has already been successfully implemented among diverse populations in multiple settings. The CDSMP is composed of six 2.5-hr sessions and covers a variety of topics, such as problem-solving skills, exercises, proper use of medication, communication skills, nutrition, and how to evaluate new treatment options [11]. The CDSMP was evaluated across 17 states over 6- and 12-month periods [11, 12]. From baseline to 6-month follow-up, the program participants showed statistically significant improvements in various health-related indicators (e.g., social/role activities limitation, depression, communication with doctor, self-rated health, pain, fatigue, and other health-related quality of life) [11]. At 12-month follow-up, the program effects on self-rated health, fatigue, pain, depression, and communication with doctors were sustained [12]. Furthermore, statistically significant improvements in medication adherence were observed at 12-month follow-up assessment [12]. Although Ory et al. [12] theorized that the long-term improvements in medication adherence could have been influenced by the short-term improvement in other health-related measures, the proposition has not been explored previously.

Of the short-term program effects of the CDSMP, self-rated health, depression, and communication with doctors are known to be associated with medication adherence. There are strong and consistent evidences for the negative association between medication adherence and depression among diverse populations [13, 14]. For example, the negative association between medication adherence and depression was observed among patients with different chronic diseases, such as arthritis [15], diabetes [16–18], heart disease [19], and hypertension [20]. Therefore, improving depressive symptoms in the short term is expected to improve medication adherence in the long term. Furthermore, previous studies suggested potential moderating effects of baseline depressive symptoms on program impacts on various health-related indicators [21, 22]. Self-rated health was associated with medication adherence in many past studies, but evidence has not always been consistent. In a study carried out in China, poor self-rated health was associated with worse medication adherence in patients with hypertension

[23], and this result is consistent with the findings from other studies [24–27]. On the other hand, a meta-analysis of 26 studies suggested that the relationship between patient adherence and health status depends on the seriousness of health conditions [28]. Communication with doctors is also acknowledged as an important correlate of medication adherence [4]. Therefore, in the current study, we hypothesized that the long-term improvements in medication adherence was influenced by the short-term improvements in self-rated health, patient communication, and depression (Fig. 1).

With the goal to explore and evaluate the long-term effects of the CDSMP on medication adherence, this study examined the effects of short-term changes in self-rated health, depression, and patient communication on long-term improvements in medication adherence. Furthermore, a subset investigation was performed among participants who were at a greater risk of medication non-adherence (i.e., participants with major depression at baseline measurement).

METHODS

Data source

The secondary data from the national CDSMP evaluation [11, 12] was used for this study. Details of the study design and data collection procedure

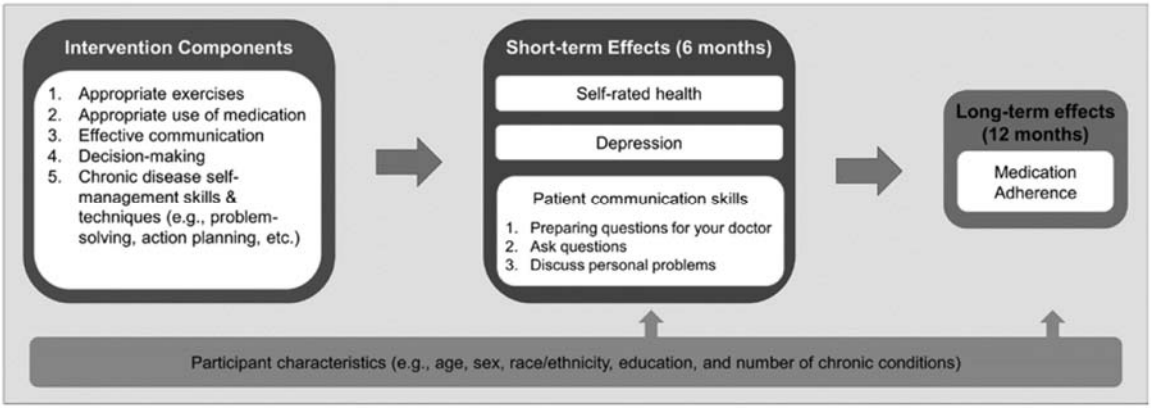

Fig. 1 | Conceptual framework that describes the hypothesized process of how the Chronic Disease Self-Management Program (CDSMP) influences long-term medication adherence.

are available elsewhere [11, 12]. Briefly, the national CDSMP evaluation used a pre–post longitudinal design to assess the effects of the CDSMP on various health-related indicators. CDSMP workshops were delivered to adults by 22 organizations in 17 states between August 2010 and April 2011. Given the nature of the current study design, the researchers did not play an active role in participant recruitment and program implementation [11, 12]. Participants were recruited by each program delivery site through self-referrals and referrals from aging, social, and health service organizations. CDSMP workshops were delivered in a face-to-face workshop format, in which small groups of participants were educated about chronic disease self-management and skills to

handle daily challenges, such as pain, fatigue, and stress. Each CDSMP workshop was composed of six sessions delivered over 6 weeks (i.e., one session per week), and each CDSMP workshop was facilitated by two trained leaders. Participants were invited to participate in survey assessments at baseline and 6- and 12-month follow-ups. The collected data included participants' sociodemographic characteristics, selfrated health, depression, communication with their doctors, and medication nonadherence. All the data used in this study, other than attendance data, were self-reported by participants using surveys.

Study participants

The national CDSMP evaluation participant eligibilities were (i) having at least one self-reported chronic condition, (ii) participating in an English or Spanish CDSMP workshop, (iii) attending at least the first or second session, (iv) participating in a CDSMP workshop for the first time, (v) completing baseline assessment, and (vi) agreeing to participate in the CDSMP evaluation. For this study, participants were further narrowed down to older adults (i.e., those who self-reported being 65 years old or older at the time of baseline assessment).

Variables

Medication nonadherence Four-item Morisky Medication Adherence Scale (MMAS-4; also known as Medication Adherence Questionnaire, MAQ) was used to measure medication nonadherence [29]. The MMAS-4 asked the following four items: (i) ever forget to take medicine, (ii) ever have problems remembering to take medicine, (iii) sometimes stop taking medicine when feel better, and (iv) sometimes stop taking medicine when feel worse. Each item was scored "yes" or "no." Participants who reported affirmative response to any of the first two items were categorized as "engaging in unintentional medication nonadherence," and the Cronbach's alpha for the two-item scale was .64. Patients who reported affirmative response to any of the last two items were categorized as "engaging in intentional medication nonadherence," and the Cronbach's alpha for the two-item scale was .61. The average score of the four items was used as an indicator for the degree of medication nonadherence overall. The reliability of the MMAS-4, measured using the Cronbach's alpha, was .56, and was similar to other studies [29, 30].

Self-rated health

A single item was used to examine the self-rated health: "In general, would you say that your health is excellent, very good, good, fair, or poor?" The response to the item ranged from excellent (=1) to poor (=5), with a higher score indicating worse health. It is a standardized item used in multiple national surveys (e.g., National Health Interview Survey and Behavioral Risk Factor Surveillance System).

Depression

The eight-item Patient Health Questionnaire (PHQ-8) was used as a measure of depression [31]. The PHQ-8 asked how often during the past 2 weeks participants

were bothered by (a) little interest or pleasure in doing things; (b) feeling down, depressed, or hopeless; (c) trouble falling or staying asleep, or sleeping too much; (d) feeling tired; (e) poor appetite or overeating; (f) feeling bad about self; (g) trouble concentrating on things; and (h) moving or speaking slowly or being very fidgety or restless. Each item was scored not at all (=0), several days (=1), more than half the days (=2), or nearly every day (=3). The sum of the eight items was used as the composite score (ranging from 0 to 24, with a higher score indicating severe depression). A score of 10 or higher was considered having major depression [31]. The reliability of the scale, among this study population was .81, measured using the Cronbach's alpha.

Communication with doctors

The following three items were used to assess what participants do during their visits to their doctors: how often do you (i) prepare questions to ask, (ii) ask questions, and (iii) discuss personal problems. Each item was scored from never (=1) to always (=6). Mean of the three items was used as the composite score (ranging from 1 to 6, with a higher score indicating better communication with doctors) [32]. The Cronbach's alpha, among this study population, was .78.

Covariates

Participants' self-reported information on age (years), sex, race/ethnicity, years of education (ranging from 1 to 23 years), number of sessions attended (ranging from 1 to 6), and number of chronic diseases were used in this study. Age was calculated by deducting the date of birth from the date of baseline assessment. Participants were asked whether they were diagnosed with the following chronic diseases: type 1 diabetes, type 2 diabetes, asthma, chronic obstructive pulmonary disease (COPD), chronic lung diseases other than COPD, hypertension, heart disease, arthritis, cancer, depression, anxiety or other mental health condition, or any other chronic condition. The number of sessions attended was calculated by summing the total number of attended sessions out of six sessions. The number of chronic conditions was calculated as the sum of the affirmative responses to each self-reported chronic condition question.

Statistical analyses

Baseline characteristics of participants were described using mean and standard deviation for interval variables and frequency and percentage for categorical variables. Independent group comparisons (e.g., $\chi 2$ test for categorical variables and two-sample t-test for continuous variables) were used to compare baseline characteristics of participants with and without 6- and 12-month follow-up assessments.

Next, multiple linear mixed models were performed to examine changes in medication adherence over time (using SAS PROC MIXED and SAS PROC GENMOD). The first set of models were performed to examine changes in medication adherences, self-rated health, depression, and patient communication from baseline to 6- and 12-month follow-up assessments after controlling for the covariates. The second set of models were performed to examine changes in medication adherence from baseline to 6- and 12-month follow-up assessments based on baseline self-rated health, depression, or

communication with doctors after controlling for the covariates. Also, effect sizes (Cohen's d) were estimated for nonbinary variables by dividing pre–post differences by pooled standard deviation. The last set of models were performed to examine changes in medication adherence from 6- to 12-month follow-up assessments based on changes in self-rated health, depression, or communication with doctors from baseline to 6-month follow-up assessments after controlling for the covariates. The last set of models were performed among the overall study population, as well as among the study population with major depression at baseline assessment.

Institutional Review Board

The secondary analysis of the data was approved by the Texas A&M University Institutional Review Board (IRB).

RESULTS

Sample characteristics

This study included 687 participants who completed at least baseline assessment. Table 1 shows baseline characteristics of participants. In average, age of participants was 74.8 years, years of education was 13, and number of chronic conditions was 2.9. The majority of participants were female (83.6%), non-Hispanic (82.8%), and White (60.6%) and attended at least four out of six CDSMP workshop sessions (80.8%). At baseline assessment, 18.1% of participants reported intentional medication nonadherence, and 38.0% reported unintentional medication nonadherence.

Table 1 also shows the comparison between those who had the complete data and those who lacked 6- or 12-month follow-up assessments. Of 687 study-eligible participants, the majority completed 6-month follow-up assessment (83.3%) and 12-month follow-up assessment (74.5%). Compared with those who did not complete 6-month follow-up assessment, those who completed 6-month follow-up assessments were more likely to be Whites ($p < .01$), had higher workshop completion rates ($p < .01$), and reported more chronic conditions ($p = .02$), better self-rated health ($p = .03$), better depressive symptoms ($p = .01$), and better communication with doctors ($p < .01$). Similarly, compared with those who did not complete 12-month follow-up assessment, those who completed 12-month follow-up assessment had higher workshop completion rates ($p < .01$) and reported better self-rated health ($p = .03$) and better depressive symptoms ($p < .01$).

Changes from baseline to 6- and 12-month follow-up assessments

Statistically significant reduction in medication nonadherence was observed from baseline to 12-month follow-up assessment, but not at 6-month follow-up assessment (Table 2). Similarly, participants showed significant reduction in unintentional medication nonadherence at 12-month follow-up assessment, but not at 6-month follow-up assessment. Also, participants showed statistically significant improvements in self-rated health, PHQ-8, and patient communication at both 6- and 12-month follow-up

assessments. The effect sizes for the observed changes were small, ranging from 0.09 to 0.16 at 6 months and 0.07 to 0.21 at 12 months.

Effects of baseline characteristics on medication nonadherence

Baseline PHQ-8 score was significantly associated with changes in medication nonadherence from baseline to 6- and 12-month follow-up assessments, $F(2, 739) = 3.83$, $p = .0222$. Compared with participants without major depression, participants with major depression reported poorer medication nonadherence, and showed greater reduction in medication nonadherence at 6- and 12-month follow-up assessments. Figure 2 shows changes in medication nonadherence (MMAS-4) from baseline to 6- and 12-month follow-up assessments among those with and without major depression at baseline assessment. Both self-rated health and patient communication at baseline were not significantly associated with changes in medication nonadherence at 6- and 12-month follow-up assessments ($p > .05$).

Table 1 | Characteristics of the study sample by follow-up assessment completion status

		6-month assessment			12-month assessment		
	Total (*n* = 687)	Completed (*n* = 572)	Not completed (*n* = 115)		Completed (*n* = 512)	Not completed (*n* = 175)	
	Mean (*SD*) or Freq (%)	Mean (*SD*) or Freq (%)	Mean (*SD*) or Freq (%)	*p*-value	Mean (*SD*) or Freq (%)	Mean (*SD*) or Freq (%)	*p*-value
Age (years)	74.8 (6.84)	74.9 (6.83)	74.3 (6.90)	.35	74.7 (6.77)	75.2 (7.06)	.36
Female	574 (83.6%)	476 (83.2%)	98 (85.2%)	.60	426 (82.6%)	151 (86.3%)	.26
Non-Hispanic	563 (82.8%)	470 (82.8%)	93 (83.0%)	.94	423 (83.3%)	140 (81.4%)	.57
White	416 (60.6%)	359 (62.8%)	57 (49.6%)	<.01*	315 (61.5%)	101 (57.7%)	.84
Education (years)	13.0 (3.73)	13.0 (3.76)	12.8 (3.59)	.72	13.0 (3.73)	12.8 (3.75)	.51
Number of chronic conditions	2.9 (1.59)	3.0 (1.58)	2.6 (1.59)	.02*	3.0 (1.53)	2.9 (1.75)	.57
Workshop completion[a]	555 (80.8%)	488 (85.3%)	67 (58.3%)	<.01*	434 (84.8%)	121 (69.1%)	<.01*
Self-rated health	3.1 (0.90)	3.0 (0.90)	3.2 (0.86)	.03*	3.0 (0.89)	3.2 (0.91)	.03*
PHQ-8	5.3 (4.62)	5.1 (4.52)	6.3 (5.02)	.01*	5.0 (4.42)	6.2 (5.08)	<.01*
Communication with doctors	2.7 (1.36)	2.7 (1.34)	2.3 (1.39)	<.01*	2.7 (1.37)	2.5 (1.34)	.25
MMAS-4	0.2 (0.26)	0.2 (0.26)	0.2 (0.26)	.73	0.2 (0.25)	0.2 (0.26)	.62
Intentional medication nonadherence	124 (18.1%)	100 (17.5%)	24 (21.2%)	.34	95 (18.6%)	29 (16.7%)	.57
Unintentional medication nonadherence	261 (38.0%)	218 (38.1%)	43 (37.4%)	.88	199 (38.9%)	62 (35.4%)	.42

PHQ Patient Health Questionnaire; MMAS Morisky Medication Adherence Scale.
[a]Attending at least four out of six CDSMP workshop sessions.
*$p < .05$.

Table 2 | Changes in health-related outcomes from baseline to 6- and 12-month follow-up assessments

Health-related outcomes	Baseline (*n* = 687) Mean (*SD*) or Freq (%)	6 month (*n* = 572) Mean (*SD*) or Freq (%)	12 month (*n* = 512) Mean (*SD*) or Freq (%)	Baseline to 6 month Effect size[a]	Baseline to 6 month *p*-value[b]	Baseline to 12 month Effect size[a]	Baseline to 12 month *p*-value[b]
Self-rated health	3.06 (0.8966)	2.96 (0.8737)	2.95 (0.9118)	0.09	.0007*	0.07	.0028*
PHQ-8	5.31 (4.6241)	4.49 (4.3191)	4.20 (4.3181)	0.16	<.0001*	0.21	<.0001*
Patient communication	2.65 (1.3591)	2.86 (1.4146)	2.89 (1.4212)	0.11	.0019*	0.17	<.0001*
Intentional medication nonadherence	124 (18.1%)	102 (17.9%)	86 (16.8%)	–	.8904	–	.5183
Unintentional medication nonadherence	261 (38.0%)	200 (35.0%)	163 (31.8%)	–	.1667	–	.0057*
MMAS-4	0.20 (0.2559)	0.19 (0.2607)	0.17 (0.2461)	0.03	.5184	0.10	.0214*

PHQ Patient Health Questionnaire; MMAS Morisky Medication Adherence Scale.
[a]Effect sizes (d) were only estimated for participants who participated in both baseline and the corresponding follow-up assessment.
[b]Adjusted for age, sex, race/ethnicity, education, number of sessions attended, and number of chronic conditions.
*p < .05.

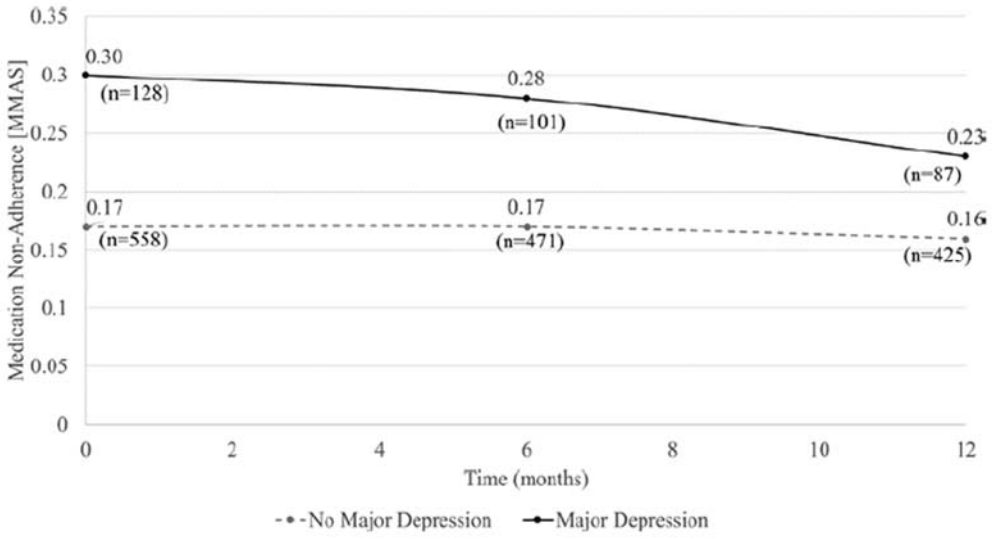

Fig. 2 | Changes in medication nonadherence from baseline to 6- and 12-month follow-up assessments among Chronic Disease Self-Management Program (CDSMP) participants with and without major depression at baseline. The numbers inside the parentheses show the sample size for each group at each time point. MMAS Morisky Medication Adherence Scale.

Table 3 | Effects of baseline to 6-month changes (Δ) in self-rated health, PHQ-8, or patient communication on changes in medication nonadherence between 6- and 12-month follow-up assessments

Improvements during the first 6 months (baseline to 6-month follow-up assessments)	Overall (n = 565)			Major depression (n = 101)		
	MMAS-4	Intentional medication nonadherence	Unintentional medication nonadherence	MMAS-4	Intentional medication nonadherence	Unintentional medication nonadherence
Model 1						
Time	−0.0181	−0.1058	−0.1884	−0.0343	−0.4843	−0.5585*
ΔSelf-rated health	−0.0078	−0.0438	−0.0843	0.0098	−0.3603	0.3428
Time × ΔSelf-rated health	−0.0006	0.0191	0.0527	−0.0073	0.9591*	−0.1638
Model 2						
Time	−0.0196	−0.1282	−0.1783	−0.0076	−0.6645	0.0541
ΔPHQ-8	−0.0053	−0.0444	−0.0105	−0.0008	−0.0394	0.0609
Time × ΔPHQ-8	0.0012	0.0333	−0.0470	−0.0077	0.0870	−0.1704*
Model 3						
Time	−0.0195	−0.1466	−0.1909	−0.0397	−0.4361	−0.5723*
ΔPatient communication	−0.0112	−0.1112	−0.0639	−0.0004	0.0651	−0.0396
Time × ΔPatient communication	0.0059	0.1580	0.0584	0.0053	0.0697	0.0116

Regression coefficients of time, Δ, the interaction of time and Δ after controlling for the covariates (age, sex, race/ethnicity, education, number of attended sessions, and number of chronic conditions). *PHQ* Patient Health Questionnaire; *MMAS* Morisky Medication Adherence Scale.
*p < .05

Effects of the first 6-month changes on the following 6-month changes in medication nonadherence

Among the overall study population, changes in self-rated health, communication with doctors, and PHQ-8 from baseline to 6-month follow-up assessments were not significantly associated with changes in self-reported medication nonadherence from 6- to 12-month follow-up assessments (p > .05; Table 3). Among participants with major depression at baseline, a unit increase in the self-rated health scale from baseline to 6-month follow-up assessment was associated with 0.5988 increase in the log-odds for engaging in intentional medication nonadherence at 12-month follow-up assessment (adjusted odds ratio = 1.82). Among participants with major depression at baseline, a unit increase in the PHQ-8 scale from baseline to 6-month follow-up assessment was associated with 0.1095 decrease in the log-odds for engaging in unintentional medication nonadherence at 12-month follow-up assessment (adjusted odds ratio = 0.90). All the regression models were performed after adjusting for age, sex, race/ethnicity, education, number of attended sessions, and number of chronic conditions.

DISCUSSION

In this study, the effects of the CDSMP on medication adherence among older adults were examined, and potential factors (e.g., baseline and first 6-month changes in self-

rated health, depression, communication with doctors) that can contribute to long-term changes in medication adherence among CDSMP participants were explored. Based on the extant literature, it was hypothesized that short-term improvements in self-rated health, depression, and communication with doctors would contribute to the long-term improvements in medication adherence. Changes at 6-month follow-up assessment were considered as short-term changes, and changes at 12-month follow-up assessment were considered as long-term changes.

Confirming the prior CDSMP evaluation papers [11, 12], this study showed that CDSMP had the statistically significant long-term effects on medication adherence, but not short-term effects. Compared with the previously published CDSMP national evaluation papers [11, 12], which included younger participants, this study focused specifically on older adults population. The magnitude of changes in medication nonadherence (effect size of 0.03 at 6-month follow-up assessment and 0.10 at 12-month follow-up assessment) was comparable with the magnitude of changes reported in the previously published CDSMP national evaluation paper (effect size of 0.03 at 6-month follow-up assessment and 0.10 at 12-month follow-up assessment) [12].

This study reaffirmed that the impacts of the CDSMP observed in a general population holds true for this specific age group. Cognitive and behavioral interventions such as the CDSMP may promote cognitive changes first, which is subsequently followed by behavioral changes [33]. Despite the statistical significance, observed changes in medication nonadherence were minimal, and a clinically meaningful implication is unknown. The small magnitude of changes can be explained by relatively high medication adherence at baseline. Furthermore, the program effects on medication adherence became more visible with the subgroup analysis among population at risk (i.e., participants with major depression at baseline), as well as after categorizing medication nonadherence behaviors into intentional and unintentional medication nonadherence.

In addition, this study demonstrated improvements in unintentional medication nonadherence,but not in intentional medication nonadherence.Intentional medication nonadherence is associated with perceived needs and concerns related to the treatment [34, 35], which were not a primary programmatic focus. The CDSMP provides an interactional setting for enhancing skills for general chronic disease self-management, such as handling stress; engaging in healthy lifestyles; communicating with their family, friends, and doctors; and seeking necessary resources. Unlike intentional medication nonadherence, unintentional medication nonadherence is associated with a lack of capacity or resources [35], and the acquirement of the general chronic disease self-management skills and tools may be related to improvements in unintentional medication nonadherence. Also, study participants reported higher rates of unintentional medication nonadherence (38%) than intentional medication nonadherence (18%), and hence had a greater room for improvements in unintentional medication nonadherence. Unintentional medication nonadherence is more prevalent in some health conditions, such as cardiovascular diseases [36], and the program may have greater benefits for this the population.

It was also observed in this study that the program effects on medication nonadherence among older adults with major depression were significantly higher than those without major depression at baseline assessment. Among those with major depression, more participants showed high medication taking behavior (MMAS-4 = 0).

From a study by Morisky et al. [29], while 75% of patients with hypertension and high medication taking behavior showed adequate blood pressure control, less than 50% of patients with hypertension and medium or lower medication taking behavior showed adequate blood pressure control. Depression is one of the most consistent determinants of medication nonadherence [13, 14]. Compared with individuals without major depression, those with major depression are more likely to have poorer medication adherence to start with, and consequently, there is more room for improvements. The finding implies that those with depressive symptoms can benefit more from the CDSMP or similar programs with regardto adhering to their medication.

Among participants with depressive symptoms, those who showed greater improvements in depression at 6-month follow-up were more likely to show greater improvements in unintentional medication nonadherence from 6- to 12-month follow-up assessments. The literature has consistently indicated the positive association between depression and medication nonadherence [13, 14]. Also, depression is associated with poorer cognition [15, 37]. Given this, it is not surprising to find the strong association between improvements in depression and improvement in unintentional medication nonadherence. In addition, the longitudinal nature of the current study adds to the literature by introducing the "time" component and enabling ordering of events.
On the other hand, improvements in intentional medication nonadherence during the final 6 months were less for participants who showed short-term improvement in self-rated health. Improved health can reduce perceived needs for the treatment, and thereby increasing the likelihood of intentional medication nonadherence [38, 39]. The perceived needs for the medication was higher among older adults who were adherent to their medication treatments than those who reported intentional medication nonadherence [40].

There were some limitations to this study. First, the study relied on the self-reported data. The self-reported data may be subject to various biases (e.g., social desirability bias). In addition, the MMAS-4 had a relatively low reliability for this population. Nevertheless, self-reported data can also provide a rich insight into the context. For example, self-reported data on medication nonadherence could be characterized into intentional versus unintentional medication nonadherence.

Second, this study employed the secondary data analysis, and the study was limited by the availability of previously identified variables of interest. Failure to include important predictors in a regression analysis can lead to omitted variable bias and inaccurate statistical inferences. Although the secondary data did not have all the key predictors of medication nonadherence (e.g., medication cost, patients' attitudes toward medication, characteristics of prescription, characteristics of providers), the data had a good number of other known predictors (e.g., self-rated health, depression, communication with doctors) for the initial exploration.

Third, lack of a comparison group could limit the study inference. The CDSMP is an evidence- based program that has been shown to be highly efficacious in improving self-rated health, depressive symptoms, and communication with doctors based on randomized controlled trials [41, 42]. The national evaluation was a pragmatic study of programmatic impacts. Thus, the program's impact on medication adherence was examined using single-group study design. Hence, the study results should be considered in light of the lack of a comparison group [11, 12, 43].

Lastly, the study provided limited interpretability over the nonsignificant outcomes, given that the study might be underpowered for some of the analyses. For example, post hoc power analyses were performed for the linear mixed effects models that aimed to examine the moderation effects of baseline self-rated health, depression, and communication with doctors on medication adherence (MMAS-4). At the significance level of 0.05, the estimated power to detect the statistical significance for the interaction term between medication nonadherence and baseline depression was 70%. Using the same significance level, the estimated powers were only 18% and 27%, respectively for the interaction term between medication nonadherence and baseline self-rated health and the interaction term between medication nonadherence and communication with doctors. However, it should also be noted that the post hoc power estimations have some methodological limitations and tend to produce low power estimates for nonsignificant outcomes. Despite the limitations, this study provides an insight about the variations in the program effects and has an important practical implication for the program delivery.

Summary and future implication

The current study examined the long-term effects of the CDSMP on medication adherence adding to the current knowledge base. A significant longterm pre–post difference in medication adherence was observed among CDSMP participants in terms of unintentional medication nonadherence. This type of nonadherence represents a primary form of medication nonadherence in older adults that can be addressed by programs such as the CDSMP. This study also indicated that the long-term program impacts on medication adherence could be influenced by short-term program impacts on other health-related indicators, such as self-rated health and depression. Although this study adds to our knowledge of translational research, the limitations point to future research efforts. Future research can be further enlightened by a more comprehensive examination that incorporates a more inclusive set of key drivers of medication nonadherence, as well as a fuller set of health and health utilization variables. Furthermore, future studies with a comparison group may be desired to provide a higher level of evidence about the relationship between the shortterm program impacts and long-term medication adherence.

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Compliance with Ethical Standards

Primary Data: This manuscript has not been previously published and is not being simultaneously submitted elsewhere. A portion of the material in this article was presented in the form of a poster at the Annual Meeting of the American Academy of Health Behaviors (2017). Also, this study is a chapter in SL's doctoral dissertation work.
Conflict of Interest: The authors declare that they have no conflict of interest.

Ethical Approval: This study used secondary data, and IRB approval for the secondary data use was received by the Texas A&M University's Institutional Review Board. No animals were involved in this project.

Informed Consent: This study used secondary data, and data given were de-identified. No consent was needed.

References

1. Centers for Disease Control and Prevention. The state of aging and health in America. 2004. Available at https://www.cdc.gov/aging/pdf/state_of_aging_and_health_in_america_2004.pdf. Accessibility verified December 18, 2017.
2. National Center for Health Statistics. Health, United States, 2015: With special feature on racial and ethnic health disparities. 2016. Available at https://www.cdc.gov/nchs/data/hus/hus15.pdf. Accessibility verified December 18, 2017.
3. Department of Health & Human Services. Observations on trends in prescription drug spending. In: ASPE Issue Brief. 2016. Retrieved from https://aspe.hhs.gov/system/files/pdf/187586/Drugspending.pdf. Accessibility verified December 18, 2017.
4. Wilson IB, Schoen C, Neuman P, et al. Physician-patient communication about prescription medication nonadherence: a 50-state study of America's seniors. J Gen Intern Med. 2007;22(1):6–12.
5. Clark B, DuChane J, Hou J, Rubinstein E, McMurray J, Duncan I. Evaluation of increased adherence and cost savings of an employer value-based benefits program targeting generic antihyperlipidemic and antidiabetic medications. J Manag Care Pharm. 2014;20(2):141–150.
6. Sokol MC, McGuigan KA, Verbrugge RR, Epstein RS. Impact of medication adherence on hospitalization risk and healthcare cost. Med Care. 2005;43(6):521–530.
7. McCowan C, Wang S, Thompson AM, Makubate B, Petrie DJ. The value of high adherence to tamoxifen in women with breast cancer: a community-based cohort study. Br J Cancer. 2013;109(5):1172–1180.
8. Iuga AO, McGuire MJ. Adherence and health care costs. Risk Manag Healthc Policy. 2014;7:35–44.
9. Haynes RB, Ackloo E, Sahota N, McDonald HP, Yao X. Interventions for enhancing medication adherence. Cochrane Database Syst Rev. 2008;(2):CD000011. doi:10.1002/14651858.CD000011.pub3.
10. Nieuwlaat R, Wilczynski N, Navarro T, et al. Interventions for enhancing medication adherence. Cochrane Database Syst Rev. 2014;(11): CD000011. doi:10.1002/14651858.CD000011.pub4.
11. Ory MG, Ahn S, Jiang L, et al. National study of chronic disease self-management: six-month outcome findings. J Aging Health. 2013;25(7):1258–1274.
12. Ory MG, Ahn S, Jiang L, et al. Successes of a national study of the chronic disease self-management program: meeting the triple aim of health care reform. Med Care. 2013;51(11):992–998.

13. Grenard JL, Munjas BA, Adams JL, et al. Depression and medication adherence in the treatment of chronic diseases in the United States: a meta-analysis. J Gen Intern Med. 2011;26(10):1175–1182.
14. DiMatteo MR, Lepper HS, Croghan TW. Depression is a risk factor for noncompliance with medical treatment: meta-analysis of the effects of anxiety and depression on patient adherence. Arch Intern Med. 2000;160(14):2101–2107.
15. Park DC, Hertzog C, Leventhal H, et al. Medication adherence in rheumatoid arthritis patients: older is wiser. J Am Geriatr Soc. 1999;47(2):172–183.
16. Chew BH, Hassan NH, Sherina MS. Determinants of medication adherence among adults with type 2 diabetes mellitus in three Malaysian public health clinics: a cross-sectional study. Patient Prefer Adherence. 2015;9:639–648.
17. Kalsekar ID, Madhavan SS, Amonkar MM, et al. Depression in patients with type 2 diabetes: impact on adherence to oral hypoglycemic agents. Ann Pharmacother. 2006;40(4):605–611.
18. Kilbourne AM, Reynolds CF, Good CB, Sereika SM, Justice AC, Fine MJ. How does depression influence diabetes medication adherence in older patients? Am J Geriatr Psychiatry, 2005;13(3):202–210.
19. Gehi A, Haas D, Pipkin S, Whooley MA. Depression and medication adherence in outpatients with coronary heart disease: findings from the Heart and Soul Study. Arch Intern Med. 2005;165(21):2508–2513.
20. Wang PS, Bohn RL, Knight E, Glynn RJ, Mogun H, Avorn J. Noncompliance with antihypertensive medications: the impact of depressive symptoms and psychosocial factors. J Gen Intern Med. 2002;17(7):504–511.
21. Jerant A, Kravitz R, Moore-Hill M, Franks P. Depressive symptoms moderated the effects of chronic illness self-management training on self-efficacy. Med Care. 2008;46:523–531.
22. Harrison M, Reeves D, Harkness E, et al. A secondary analysis of the moderating effects of depression and multimorbidity on the effectiveness of a chronic disease self-management programme. Patient Educ Couns. 2012;87(1):67–73.
23. Lee GKY, Wang HHX, Liu KQL, Cheung Y, Morisky DE, Wong MCS. Determinants of medication adherence to antihypertensive medications among a Chinese population using Morisky Medication Adherence Scale. PLoS ONE, 2013;8(4):e62775.
24. Cho YI, Lee SY, Arozullah AM, Crittenden KS. Effects of health literacy on health status and health service utilization amongst the elderly. Soc Sci Med. 2008;66(8):1809–1816.
25. Gadkari AS, McHorney CA. Unintentional non-adherence to chronic prescription medications: how unintentional is it really? BMC Health Serv Res. 2012;12:98.
26. Kuo SZ, Haftek M, Lai JC. Factors associated with medication non-adherence in patients with end-stage liver disease. Dig Dis Sci. 2017;62(2):543–549.
27. Lee YM, Yu HY, You, Son YJ. Impact of health literacy on medication adherence in older people with chronic diseases. Collegian. 2017;24(1):11–18.
28. DiMatteo MR, Haskard KB, Williams SL. Health beliefs, disease severity, and patient adherence: a meta-analysis. Med Care. 2007;45(6):521–528.
29. Morisky DE, Green LW, Levine DM. Concurrent and predictive validity of a self-reported measure of medication adherence. Med Care. 1986;24(1):67–74.

30. Parada H Jr, Horton LA, Cherrington A, Ibarra L, Ayala GX. Correlates of medication nonadherence among Latinos with type 2 diabetes. Diabetes Educ. 2012;38(4):552–561.
31. Kroenke K, Strine TW, Spitzer RL, Williams JB, Berry JT, Mokdad AH. The PHQ-8 as a measure of current depression in the general population. J Affect Disord. 2009;114(1–3):163–173.
32. Lorig K, Stewart A, Ritter P, Gonzalez V, Laurent D, Lynch J. Outcome Measures for Health Education and Other Health Care Interventions. Thousand Oaks, CA: Sage Publication.
33. Bandura A, Adams NE, Beyer J. Cognitive processes mediating behavioral change. J Pers Soc Psychol. 1977;35(3):125–139.
34. Mukhtar O, Weinman J, Jackson SH. Intentional non-adherence to medications by older adults. Drugs Aging. 2014;31(3):149–157.
35. Clifford S, Barber N, Horne R. Understanding different beliefs held by adherers, unintentional nonadherers, and intentional nonadherers: application of the Necessity-Concerns Framework. J Psychosom Res. 2008;64(1):41–46.
36. Molloy GJ, Messerli-Bürgy N, Hutton G, Wikman A, Perkins-Porras L, Steptoe A. Intentional and unintentional non-adherence to medications following an acute coronary syndrome: a longitudinal study. J Psychosom Res. 2014;76(5):430–432.
37. Brown SC, Glass JM, Park DC. The relationship of pain and depression to cognitive function in rheumatoid arthritis patients. Pain. 2002;96(3):279–284.
38. Tibaldi G, Clatworthy J, Torchio E, Argentero P, Munizza C, Horne R. The utility of the necessity–concerns framework in explaining treatment non-adherence in four chronic illness groups in Italy. Chronic Illn. 2009;5(2):129–133.
39. Horne R, Chapman SC, Parham R, Freemantle N, Forbes A, Cooper V. Understanding patients' adherence-related beliefs about medicines prescribed for long-term conditions: a meta-analytic review of the necessity-concerns framework. Plos One. 2013;8(12):e80633.
40. Bae SG, Kam S, Park KS, et al. Factors related to intentional and unintentional medication nonadherence in elderly patients with hypertension in rural community. Patient Prefer Adherence. 2016;10:1979–1989.
41. Lorig KR, Sobel DS, Stewart AL, et al. Evidence suggesting that a chronic disease self-management program can improve health status while reducing hospitalization: a randomized trial. Med Care. 1999;37(1):5–14.
42. Lorig KR, Ritter P, Stewart AL, et al. Chronic disease self-management program: 2-year health status and health care utilization outcomes. Med Care. 2001;39(11):1217–1223.
43. Ritter PL, Ory MG, Laurent DD, Lorig K. Effects of chronic disease self-management programs for participants with higher depression scores: secondary analyses of an on-line and a small-group program. Transl Behav Med. 2014;4(4):398–406.

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