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Use of the Refill Function through an Online Patient Portal is Associated with Improved Adherence to Statins in an Integrated Health System

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Abstract

Background—Online patient portals are being widely implemented, but their impact on health behaviors are not well-studied.

Objective—To determine whether statin adherence improved after initiating use of the portal refill function.

Research Design—Observational cohort study within an integrated healthcare delivery system.

Subjects—Diabetes patients on statins who had registered for online portal access by 2010. 8,705 subjects initiated online refill function use within the study window, including “exclusive” and “occasional” users (i.e., requesting all vs. some refills online, respectively). Using risk-set sampling, we temporally matched 9,055 reference group patients who never used online refills.

Measures—We calculated statin adherence before and after refill function initiation, assessed as % time without medications (non-adherence defined as gap >20%). Secondary outcome was dyslipidemia (LDL ≥100). Difference-in-differences regression models estimated pre-post changes in non-adherence and dyslipidemia, comparing refill function users to the reference group and adjusting for age, sex, race/ethnicity, medications, frequency of portal use, and outpatient visits.

Results—In unadjusted examinations, non-adherence decreased only among patients initiating occasional or exclusive use of the refill function (26 to 24%, and 22 to 15%, respectively). In adjusted models, non-adherence declined by an absolute 6% (95% CI: 4–7%) among exclusive users, without significant changes among occasional users. Similar LDL decreases were also seen among exclusive users.

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Conclusions—Compared to portal users who did not refill medications online, adherence to statin medications and LDL levels improved among diabetes patients who initiated and exclusively used the patient portal for refills, suggesting that wider adoption of online refills may improve adherence.

Keywords

patient portals; medication adherence; health information technology

Introduction

The management of outpatient chronic conditions is increasingly being supported by online patient portals. Patient portals (also sometimes referred to as shared medical records or personal health records) can provide internet-based interactions with the health care system, such as scheduling appointments, reviewing laboratory results, and requesting medication refills.(1–5) Portal functions are integral to the “meaningful use” standards for health information technology stipulated in federal legislation, as patient engagement with portals will be tied to incentives and, eventually, penalties for health systems. (6)

Patient portals may also increase clinical efficiency for patients and improve patient outcomes such as diabetes process and outcome measures.(7–10) However, prior studies have not been able to address confounding due to self-selection into patient portal use, have been cross-sectional and thus unable to establish the time ordering, or have been unable to focus on a specific portal feature in relation to outcomes. No study to date has evaluated the impact of patient portals on medication adherence in a longitudinal fashion using rigorous methodology.

We investigated whether ordering refills using the patient portal would benefit medication adherence and optimize risk factor management for this population. Specifically, we evaluated whether initiating use of the medication refill function on the patient portal was associated prospectively with better adherence to a statin and better LDL control, within a large, well-characterized and diverse cohort of adult diabetes patients cared for in an integrated healthcare delivery system in Northern California.

Methods

Study setting

Patients for this analysis were selected from the diabetes registry at Kaiser Permanente Northern California (KPNC), which has been described in detail previously.(11–15) Briefly, the registry uses health plan data to identify patients with diabetes using a validated algorithm.(16) KPNC maintains a closed pharmacy system with almost complete capture of pharmacy utilization.(17)

Kp.org

The online portal at www.kp.org allows all registered users access 1) requesting medication refills (including checking the status of the refill), 2) viewing medical history and office visit

summaries, 3) viewing laboratory results, 4) scheduling appointments, and 5) sending and receiving secure messages (i.e., e-mails) with providers. This portal has been available to all Kaiser patients in Northern California since 2005. It is available in English only. Sixty percent of all KPNC adult members were registered users as of 12/31/12.

Sample Selection

We sought to compare similar groups of patients already engaging with the portal, rather than comparing to patients who may have differing interests and abilities in using online resources. Therefore we included only registered users of the portal in both the exposed and reference groups to minimize potential selection bias.

We selected all diabetes patients who were health plan members as of 1/1/06, at least 18 years old, had no gaps >2 months in membership, and had prescription drug benefits (N=125,205) (Figure). We then excluded 12,183 patients who had no dispensing of a statin medication during the study period (2006–2010) and then 40,450 who had not registered for kp.org by 12/31/10. Of the remaining patients, 24,764 had used kp.org to refill a statin one or more times during the study period (“refill function users”); we defined as our exposed group. Another 25,995 patients were identified as the reference group pool because they had actively used at least one of the other portal features (appointment, lab results, and/or secure messaging), but had never used the refill function. This reference group refilled medications through other available mechanisms – that is, in-person at Kaiser pharmacies or via the telephone refill system. Importantly, all reference patients were prescribe statin medications and thus needed to refill at broadly similar intervals to maintain their medication supply.

For each of the 24,764 online “refill function users,” the index date was the date each patient first used kp.org to request a refill for a statin between January 1, 2006 and December 31, 2010. In order to calculate a stable estimate of adherence, a minimum of 2 refill intervals (time bounded by 2 dispensings) are required at both the pre-index and post-index periods. Thus, we excluded 11,015 and 5,044 patients who had less than 2 statin dispensings in the pre and post-index periods, respectively, leaving us with a final eligible cohort of 8,705 refill function users. Because the typical medication supply at Kaiser is 100 days, this roughly corresponds to 6 months; but those who are non-adherent would have longer time windows in between their dispensings. Possible reasons for insufficient number of dispensings could be if patients were newly prescribed a statin, if they were new entrants into the health plan, or if they were newly registered on kp.org.

We used risk-set sampling(18) to select from the pool of patients who were registered portal users but did not request any medication refills online. We sampled proportionally by year, such that the distribution of the index dates in the reference group temporally approximated the distribution of the index dates in the refill function user group, in order to account for background differences in adherence over time. Within the sampled year, we also randomly selected an index refill with which to calculate baseline and follow-up adherence. Thus, the reference group of statin users was anchored to a randomly selected refill within a randomly selected calendar year. Patients without any statin dispensing in their randomly selected index year and patients who lacked the 6-month timeframe at baseline and follow-up were excluded, leaving an analytic sample of 9,055.

DISTANCE subsample

For 12% of the sample, we also had access to detailed survey data from the Diabetes Study of Northern California (DISTANCE). This facilitated a sub-analysis with adjustment for additional, potential confounders of an association between patient portal refill use and adherence to statins (i.e., health literacy, education, English proficiency, marital status, and locus of control).

Outcomes of Interest

We chose medication as the primary outcome of interest because it is proximally related to the kp.org refill function. We examined a single medication therapy (statins) to increase comparability of refill behaviors. Statins are the most predominant class of lipid-lowering therapy and are widely prescribed in diabetes. In addition, statin adherence is closely tied to low-density lipoprotein (LDL) levels.(19)

For each patient, we calculated adherence to statins in the baseline and follow-up periods separately, based on the continuous medication gap (CMG) methodology,(17, 20) which was validated previously in this population (17). The CMG is the proportion of time for which the patient has no medication supply (one minus the ratio of total days supply dispensed divided by the sum of days between the first and last fill in the intervals). Patients were assumed to have no medication stockpile at baseline. We defined “non-adherence” as lacking a medication supply for more than 20% of the observation time (CMG>20%).(17) When considering two refill intervals of 200 days total, those who refill on day 251 or later would have a gap in medications >20% (i.e., without medication 51 days out of 251, or 20.3% of the time) and classified as non-adherent.

We conducted additional sensitivity analysis by examining LDL control as a secondary outcome of initiating use of the refill function. This analysis was restricted to individuals with poor baseline adherence (CMG>20%) for statins. Using the same pre-post design with controls, we compared the baseline LDL (the last LDL recorded in the electronic medical record during the 12 months prior to the index date) to the follow-up LDL measure (the last measure recorded in the electronic medical record during the 12 months after the index date). LDL was dichotomized based on clinical guidelines (i.e., <100 mg/dL as good control vs. ≥100 mg/dL as poor control or dyslipidemia).

Exposure of interest

Our primary exposure, kp.org refill function initiation, was categorized into three groups. The reference group consisted of active portal users currently on statins who never used the online refill function. We compared the reference group to refill function users. Refill function users were stratified as: 1) “occasional users,” those that requested statin medication refills via kp.org at least once (but not always), and 2) “exclusive users,” those that requested all of their statin refills via kp.org. The two-level exposure allowed us to examine a dose-response effect of the online refill function.

Covariates

In adjusted models, we included covariates that we felt were confounders of refill function use and statin adherence. Model specification was guided by constructing a directed acyclic graph (DAG), depicting hypothesized causal relationships and temporal ordering between the exposure (initiating use of the online refill function), outcome of interest (medication adherence), and related variables. We used established rules for determining the necessary subset of covariates to estimate the direct effect of kp.org refill function initiation on statin adherence and LDL control.(21, 22)

Our adjusted models included age (in years), sex, race/ethnicity (White, Black, Latino, Asian (Chinese, Japanese, Korean, and Vietnamese), Filipino, and Other), number of chronic medications, number of total kp.org sign-ons, and number of outpatient visits – all assessed at baseline from the electronic medical record.

In a sensitivity analysis among a subset of survey respondents from DISTANCE, we examined whether findings persisted after adding potential confounding variables self-reported on the survey instrument. These included: education (in categories of high school graduate or less, some college, or college graduate or more), English proficiency (yes/no), health literacy (yes/no), internal vs. external locus of control, neuroticism, conscientiousness and marital status (married vs. not). English proficiency and marital status were each assessed with a single, validated item(23), self-reported health literacy was assessed using a validated, three-item summative scale(24–26), neuroticism and conscientiousness were measured using a validated scale (27, 28) and locus of control was assessed with a single item(29, 30).

Analytic approach

In order to best approach causal inference using observational data, we employed a difference-in-differences framework, which is based on pre-post design with a reference group(31, 32). The reference group serves to provide an estimate of the background, expected change in the outcome which is then used to discount (by subtracting from) the change observed in the exposed group. This conservative approach yields the amount of change in statin adherence associated with initiating refill function use (the exposure) that is above and beyond the expected (background) change in adherence associated with secular trends, time, or aging. For unadjusted analyses, we compared the proportions of non-adherence at baseline and follow-up among the 3 exposure categories (never, occasional, or exclusive). For adjusted analyses, we specified regression models using a difference-in-differences framework.(33, 34) We calculated the adjusted relative risk (and risk difference) of non-adherence comparing refill function users to the reference group using modified log Poisson (and least-squares) regression models, respectively.(35–37) Our models adjusted for baseline adherence as well as all covariates listed above. Finally, we conducted a sub-group analysis among DISTANCE respondents by including the additional potential confounders collected via the survey. All regression models were weighted to account for oversampling of minorities (i.e., non-proportional survey sampling fractions) and survey non-response. (38)

In a validation analysis, we examined the association between initiating refill function use and LDL control, among patients who were non-adherent to statin medications at baseline. We use the same difference-in-differences approach described above to model relative risks and risk differences to assess the impact of initiating kp.org use on lipid control in the follow-up period. We controlled for baseline LDL as well as age, sex, race/ethnicity, number of chronic medications, number of kp.org signons and number of outpatient visits, and again accounted for the secular trends in LDL expected among those not initiating kp.org refill function. Finally, we ran a mediation analysis, adding adherence to the model to determine if the effect on LDL control was mediated by adherence in the follow-up period.

Results

Among the 17,760 diabetes patients in the main sample (Table 1), the mean age was 62, and the patients were racially/ethnically diverse (40% non-white). The cohort was also medically complex, with a mean of more than 6 chronic medications prescribed and 11 outpatient visits per year. Most (84%) had an LDL within the target of <100 mg/dL. Table 1 suggests that the three groups were relatively homogeneous, except adherence at baseline was highest in the reference group compared to the exposed groups.

The unadjusted prevalence of medication non-adherence did not change pre-post among non-users of the kp.org refill function (reference group). In contrast, non-adherence decreased from from 26% to 24% among occasional users (p=0.01) and from 22% to 15%, p< 0.001) among those who exclusively refilled their medication online using kp.org.

In adjusted models, there were no significant differences when comparing occasional users of the online refill function to non-users.. However, adherence improved significantly among exclusive users of the kp.org refill function, with the prevalence of non-adherence decreasing by an absolute 6% (95% CI: 4–7% decrease), after accounting for expected adherence changes based on the reference group (Table 2). Similarly, in the DISTANCE sub-sample, in which we were able to additionally adjust for health literacy, education, English proficiency, internal locus of control, conscientiousness, neuroticism and marital status (n=1,584), the prevalence of non-adherence to statin medication declined by an absolute 9% (95% CI: 3–16% decrease) in the exclusive use group compared to the reference group.

Among patients who were non-adherent to statins at baseline period (N=3,887), initiation of the refill function in kp.org resulted in an absolute 6% decrease in the prevalence of poor LDL control (i.e., LDL≥100 mg/dL) (95% CI: 3%–9%) after accounting for changes in the reference group.(Table 3). Adding adherence in the follow-up period to the model attenuated this effect, suggesting that the LDL improvement was partially mediated by improved adherence. In an alternative specification of LDL change over time (not shown), we examined LDL as a continuous value and found that LDL decreased by 3.1 mg/dL (95% CI −5.4, −0.8) among those initiating exclusive use compared to non-users. This effect size was attenuated to a 2.1 mg/dL decrease and became non-significant (95% CI: −4.4, 0.18) when adjusting for follow-up adherence. Again, there were no significant differences between occasional users and non-users.

Discussion

We found that initiating and maintaining use of the medication refill function in the online patient portal to request statin medication refills was associated with subsequent improvement in medication adherence and LDL control. Using a pre-post design with a carefully selected reference group, we found that patients who switched to exclusively requesting medication refills online significantly improved their statin adherence. Furthermore, when analyzing this association within a smaller sample of patients for whom we had access to additional social and demographic characteristics, this significant improvement in adherence persisted and was amplified. While our observational study cannot establish the underlying mechanism for this association, this is an important step in understanding whether benefits imparted by patient portals extend beyond simply providing convenient access.

Our findings support prior work on patient portals for diabetes management. Specifically, diabetes patients at Group Health who used secure messaging had significantly lower hemoglobin A1c.(9) In addition, a recent study at HealthPartners found that diabetes patients exposed to an EHR had improved process and outcome measures.(39) Similarly, diabetes patients who used the personal health record at the Cleveland Clinic had improved hemoglobin A1c compared to non-users.(8) Our study builds upon this body of work that suggests better diabetes care and outcomes for patients using online portals, within an integrated healthcare delivery system with a mature and multi-function portal.

In addition to retrospectively examining portal use at the patient rather than clinic or system level, we employed a rigorous design that isolates use of a single portal feature (the online refill function) with a tightly linked outcome on the causal pathway (medication adherence). Our reference group selection identified the most similar diabetes patients (that is, those who are actively refilling their statins, who were already registered for kp.org in a similar timeframe, and used other online features) the selection bias that might exist among those choosing to use portals as a part of their care management. Finally, the closed pharmacy system at Kaiser allowed us to assess adherence comprehensively. This study therefore brings the field closer to understanding the specific mechanisms through which portal use may influence outcomes.

Improved medication adherence associated with patient portal use may be attributable to the convenience of requesting refills online, or to increase patient activation. Online refills could reduce structural barriers to acquiring medications (e.g., time and/or cost of transportation to the pharmacy), which are often not discussed between patients and providers. (40, 41) Although not specific to refill functions, previous qualitative research has suggested that collaborative care delivered through shared electronic medical records can result in increases in diabetes patients' self-reported health awareness.(42)

Among those with sub-optimal adherence, we found a larger improvement in LDL control among those initiating exclusive use of the patient portal for refills. Our mediation model suggests that this LDL improvement was partially explained by improved statin adherence. Because LDL control has been associated prospectively with cardiovascular outcomes in

multiple studies,(19, 43–45) the finding that patient portals can support LDL lowering is very promising.

Despite its strengths, this study does have limitations. First, this is an observational study, and we cannot definitively establish that initiation of patient portal refills improved adherence. However, this pre-post design with a reference group has the advantage of eliminating much of the selection bias and potential for reverse causality associated with cross-sectional comparisons of patient portal users to non-users, as prior studies have done.(34, 46, 47) The size and detailed characterization of the study sample allowed for selection of a reference group who were patient portal users as well as having demographic characteristics similar to the exposed group. Because the current health policy environment supports the widest possible implementation of patient portals, a randomized trial of patient portal use is unlikely to be conducted. Thus, this type of natural experiment is the most practical way to analyze the associations. We acknowledge that while our study suggests a causal relationship, it cannot identify the actual mechanism behind this increased adherence. One hypothesis is that adherence improved because of the convenience of using the online patient portal for refills. We cannot rule out that all the people in the refill initiation group experienced a change in their underlying motivation or self-efficacy, leading to increased adherence, or that such individuals have personality traits (eg neuroticism or conscientiousness) that promote both persistent use of the refill function and persistent adherence when the portal is made available. While we acknowledge that motivation is a potential residual confounder, the subjects who do not initiate kp.org for online refills (i.e., the reference group) also include patients who may be highly motivated toward improving adherence and can be enabled to do so via other convenient mechanisms (via phone, via mail-order). While we are unable to identify the mechanisms behind the findings in this study, we suspect that the initiation of online refills may facilitate adherence to a greater degree than the alternative modes of acquiring refills and thus support highly activated patients. Similarly, those with better adherence may also be engaging in other healthy behaviors which lead to LDL improvements, such that it is not completely mediated by statin adherence. Finally, while both the exposed and reference groups were ongoing statin users in this study, we cannot be certain that the observed effect would remain were we to have broadened the sample to include those who discontinued statin use altogether. However, we chose statins because of their likelihood to be used continuously for long periods of time, and therefore think the issue of planned medication discontinuation is minor within our sample.

Second, our measure of adherence, continuous medication gaps, is not a measure of actual medication ingestion, but rather the proportion of time in which the patient has no medicine (i.e., gaps). Nevertheless, it is a widely accepted and validated measure of adherence, and is based on dispensed medications as opposed to prescriptions or self-report (which is subject to social desirability bias).(17) Third, because this study took place in an integrated health system in which all patients are insured, results may not be applicable to other health settings or patient populations. Finally, kp.org is a robust health portal, and its functionality and usability may exceed that of other patient portals, making the results most generalizable to other portal systems with similar online refill functionality.

Internet-based patient portals are becoming increasingly important to ambulatory health care delivery. This study provides some concrete support for the belief that patient portals may facilitate self-management. Patient portals, as well as the use of EMRs, which have also been associated with improved clinical control among diabetes patients in poor control,(48) represent an innovative structural feature of health care systems that have a role in efforts to improve care delivery and health outcomes. In order to spread patient portal use widely among chronic disease populations, portals should be implemented across multiple health systems, and designed to be usable for the diverse chronic disease populations most in need of support.(49)

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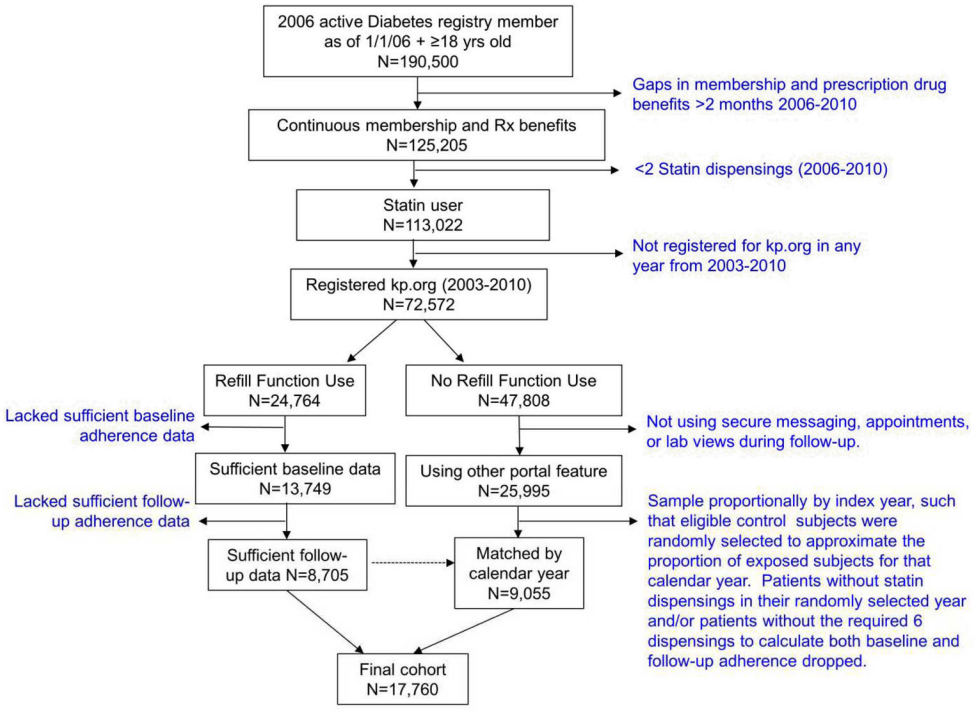

Figure.
Cohort Flowchart

Table 1

Baseline Sample Characteristics by KP.org Refill Function Use

Mean (s.d.) or column %	Total	KP.org refill function user groups			
		Reference group	Exposure groups		
	n=17,760	No use (n=9,055)	Occasional use (n=5,418)	Exclusive use (n=3,287)	P-value
Age (s.d.)	62.7 (11.3)	64.6 (11.0)	60.1 (11.3)	61.9 (10.8)	<0.001
Female	46	46	48	43	<0.001
Race					<0.001
African American	7	8	8	5	
Asian	10	10	10	11	
Caucasian	58	58	56	62	
Filipino	6	7	6	6	
Latino	9	9	10	8	
Mixed/other/unknown	9	9	10	9	
Upper quartile of Charlson co-morbidity scale	28	30	25	26	<0.001
Use of other kp.org features					
Secure messaging	78	71	85	86	<0.001
Appointments	54	37	70	72	<0.001
Lab view	86	79	93	94	<0.001
Number of Chronically Used Medications	6.7 (3.1)	6.6 (3.1)	6.7 (3.1)	6.8 (3.0)	0.02
Number of Outpatient visits	11.4 (12.2)	11.5 (12.0)	11.5 (13.1)	10.9 (11.2)	0.08
Proportion Adherent to Statin Medications Pre-baseline (CMG < 20%)	78	81	74	78	<0.001
LDL<100 mg/dL	84	84	82	87	<0.001
DISTANCE respondents	12	12	12	13	0.08

DISTANCE subsample	n=2178	No use (n=1,072)	Occasional use (n=668)	Exclusive use (n=438)	P-value
Education (n=2,148)					
No degree	8	8	7	10	0.36
High school	24	23	26	25	
Some college	25	25	26	23	
College graduate or more	43	45	41	42	
Married (n=2,126)	76	73	80	78	0.003
Limited English proficiency (n=1,919)	3	4	3	4	0.78
Inadequate health literacy (n=1,633)	59	61	54	63	0.01

Note: Missing survey data among DISTANCE subsample: N for education=2,148; N for marital status=2,126; N for language=1,919; N for health literacy=1,633

Table 2

Risk of Non-Adherence to Statins by KP.org Refill Use

	Adjusted Model 1: Full sample (n=17,760)		**Adjusted Model 2: DISTANCE survey subsample with additional confounders (n=1,601)**	
	RR (95% CI)	**Risk Difference (95% CI)**	**RR (95% CI)**	**Risk Difference (95% CI)**
No refill function use (reference)	---	---	---	---
Occasional use	1.04 (0.98, 1.10)	0.01 (−0.004, 0.02)	0.88 (0.67, 1.15)	−0.03 (−0.10, 0.04)
Exclusive use	**0.71 (0.65, 0.78)***	**−0.06 (−0.08, −0.05)***	**0.58 (0.39, 0.86)***	**−0.10 (−0.17, − 0.04)***

* p-value <0.05

Model 1 adjusts for baseline medication adherence age, sex, race, number of medications, and outpatient utilization visits

Model 2 adjusts for baseline medication adherence, age, sex, race, health literacy, education, limited English proficiency, marital status, number of medications, and outpatient utilization visits

RD=Risk Difference

RR=Relative Risk

Table 3

Risk of Poor LDL Control (≥100 mg/dL) by KP.org Refill Function Use, Among Those Non-Adherent to Statins at Baseline (n=3,887)

	Fully Adjusted†		+Mediation by Follow-up Adherence∫	
	RR (95% CI)	**RD (95% CI)**	**RR (95% CI)**	**RD (95% CI)**
No refill function use (Ref)	--	--	--	--
Occasional use	0.99 (0.86, 1.15)	−0.002 (−0.03, 0.03)	1.00 (0.86, 1.15)	−0.001 (−0.03, 0.03)
Exclusive use	**0.70 (0.56, 0.87)***	**−0.06 (−0.09, −0.03)***	**0.75 (0.60, 0.94)***	**−0.04 (−0.08, −0.01)***

*p-value <0.05

†Fully adjusted: baseline LDL, age, sex, race, number of medications, and outpatient utilization visits

∫Mediation model also adjusts for follow-up medication adherence

RD=Risk Difference

RR=Relative Risk