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OA – education and psychological aspects Measurements of medication adherence in diabetic patients with poorly controlled HbA_{1c}

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Abstract

Aims—To assess pharmacy claims and self-report data as measures of medication adherence and to describe baseline characteristics of subjects in the Improving Diabetes Outcomes Study.

Methods—Multi-ethnic, lower-income, insured adults (n=526) in New York City with type 2 diabetes were enrolled in a randomized controlled behavioural intervention study delivered by telephone. Baseline data were examined, including HbA_{1c}, objective measures of diabetes medication adherence (claims data medication possession ratio (MPR)), and 2 self-report measures (Morisky Medication-taking Scale and the medication-taking item of the Summary of Diabetes Self-care Activities (SDSCA)). Associations of highest tertile HbA_{1c} (>9.3%) with lowest tertile MPR (<42%) were assessed with logistic regression models adjusting for potential confounders. Subset analyses were performed based on assessment of potential interaction.

Results—Participants (mean±SD age 56±7 years) had median (interquartile range) HbA_{1c} 8.6 % (8.0, 10.0). Correlations of baseline MPR with Morisky score and SDSCA medication-taking item were strongly significant (both rho=0.21, p<.001). Lowest MPR was significantly (p=0.008) associated with highest HbA_{1c} in the group as a whole and among the subset taking ≥2 oral glucose lowering agents (OGLA) (p=0.002), but not among the subset taking only 1 (p=0.83). Self-report adherence measures were not significantly associated with HbA_{1c} in either the whole group or either subset.

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Conclusions—These results support the validity of MPR as an adherence measure for OGLA among insured diabetes patients with poorly controlled HbA_{1c}, especially those taking 2 OGLA.

Keywords

medication adherence; glycaemic control; medication possession ratio; oral glucose-lowering agents; HbA_{1c}

Introduction

Although glycaemic control can reduce morbidity and mortality in type 2 diabetes (1), as many as 43% of people with known diabetes in the U.S. have glycated haemoglobin (HbA_{1c}) $\geq 7.0\%$ (2). Since medication, diet and exercise can be very effective in achieving control (1,3,4,5), one can surmise that suboptimal control is due in part to challenges to medication adherence and self-management. Assessing adherence, especially medication adherence, can have substantial importance for both clinical practice and research studies, but no universally accepted methods exist for such assessment from administrative or self-report data (6).

The Improving Diabetes Outcomes with Medication, Diet and Exercise (I DO) study was conceived as a translational, randomized controlled trial to test behavioural interventions among people having difficulty managing their type 2 diabetes (7). The underlying hypothesis of the study was that a culturally-tailored, telephone, self-management support intervention by health educators without clinical training would improve glycaemic control and diabetes self-management compared to an active control of mailed educational materials without the activation of the self-management support.

Unique to this study of persons with diabetes in the U.S. was that all participants were covered by a labour union-sponsored comprehensive health plan enabling participants to receive health care and medications with little or no out-of-pocket expense. Thus medication adherence would not be confounded by ability to pay for medications. Moreover, this study was unique in having access to electronic pharmacy claims data, along with two self-report measures of medication adherence. While follow-up data are still being processed, we now report a cross-sectional analysis of baseline data regarding associations of multiple measures of medication adherence.

Subjects and Methods

Participants and setting

Potential participants were adult (≥ 30 years old) members of the 1199SEIU Benefit and Pension Funds (Fund), which provides health benefits for members of the 1199SEIU union of health care workers based in New York City. Fund members were current or recent full-time health workers or their spouses. Workers were primarily home health attendants and nursing home and hospital workers who were eligible for full coverage of medical visits, hospital admissions, laboratory tests and prescription medications. Although some 1199SEIU members have advanced technical or professional degrees, the majority are service and clerical workers. Eligibility criteria included: ability to read and speak English

or Spanish, expectation of being in the New York area for the protocol duration, and no evidence of cognitive impairment. In addition, all participants had been prescribed one or more oral glucose lowering agent (OGLA) in the year prior to enrollment and had an entry capillary blood HbA_{1c} $\geq$ 7.5%. A goal of the I DO study was to test interventions among individuals who might not participate in conventional face-to-face diabetes education programs. Thus, the protocol excluded face-to-face contact with participants. Oral informed consent and Health Insurance Portability and Accountability Act (HIPAA) authorization were obtained by telephone with approval of the Committee on Clinical Investigations (institutional review board) of the Albert Einstein College of Medicine. Those currently attending any diabetes education program or participating in any other study were also excluded to prevent contamination of the study protocol.

Recruitment

Study staff telephoned Fund members who were potentially eligible according to prescription refill database records. After initial eligibility was confirmed and oral consent documented, a screening questionnaire was administered and an HbA_{1c} test kit sent. Those with capillary HbA_{1c} $\geq$ 7.5% were enrolled into the study.

Measures

HbA_{1c}. Mail-in kits (“Lab-in-an-envelope”) (8) were obtained from a vendor (Home Healthcare Laboratory of America (HHLA)) whose HbA_{1c} process (alternately called “filter paper” or “dry-dot”) had been approved by the National Glycohemoglobin Standardization Program (NGSP) (9). In this method, participants used a spring-loaded lancet to draw blood from their fingertips and fill in 1 to 3 circles (1.2 cm diameter) on a special filter paper card that was then mailed back in a pre-paid envelope for analysis by HHLA. A Roche analyzer was used to process the specimens, and values comparable to standard laboratory assays were reported. HbA_{1c} values from the filter paper method have been reported to correspond to those obtained by conventional venous whole-blood samples (10). Participants were asked to call the health educator to guide them through the blood sampling. If insufficient blood was obtained for a valid result, the participant was sent another kit to repeat the test.

Medication adherence

Pharmacy claims (administrative) data indicating the date and number of pills dispensed to participants were used to calculate a medication possession ratio (MPR), a measure of adherence that in various forms has been used in many studies (11). The OGLA were grouped by the claims data defined therapeutic classes. For each class of OGLA taken by a participant within the previous year, the number of pill-days available from filled prescriptions was calculated from the Fund's administrative database. This number divided by 365 and expressed as a % (range 0 through 100) was defined as the MPR for that class of drug (12). For those participants taking more than one class of OGLA, an average MPR was calculated from the individual class MPRs. Since Fund formulary medications are without cost to members, it was deemed unlikely that participants would obtain OGLA outside of the Fund. Alternate versions of MPR were also calculated. In one set, the MPR took into account “terminal gaps,” periods alternately $\geq$ 120 and $\geq$ 270 continuous days without medication. These gaps were subtracted from the denominator under the assumption that

missing so many days may have been a deliberate choice of the doctor or participant. Other alternative MPRs for those taking more than one class of OGLA included using alternately the minimum or maximum instead of the mean MPR as well as constructing a single MPR for all OGLA irrespective of drug class. MPRs were analyzed as a continuous variable and also categorized by tertiles. Insulin and non-insulin injectable medications were recorded separately as present or absent.

The Summary of Diabetes Self Care Activities (SDSCA) (13) scale was administered including one medication item: how many days in the most recent week diabetes pills were taken as prescribed. This was treated as a non-parametric continuous variable (0 through 7) and categorized as adherent (≥ 7 days) or not. Other SDSCA questions addressed nutrition and physical activity and were analyzed similarly. The 4-item Morisky Self-Reported Medication-Taking Scale (14) (Morisky scale) was also administered, and scores ≤ 2 were considered poor adherence. Self-reported demographics including sex, age, race/ethnicity, work status, marital status, income, education, and birthplace were collected, as were other participant characteristics including self-reported height and weight for calculating body mass index (BMI), years with diabetes, and insulin use in the previous year.

Statistical analysis

Bi-variate associations were assessed by parametric or non-parametric tests as appropriate. P for trend was assessed across tertiles of MPR. HbA_{1c} was highly skewed and left-truncated due to the entry criterion and could not be normalized by log transformation. As an outcome variable for multivariable logistic regression, HbA_{1c} was dichotomized as highest tertile of HbA_{1c} versus else. For sensitivity analyses HbA_{1c} was stratified as less than and $\geq 9.0\%$ and highest tertiles within these strata were defined. The number of OGLA reported being taken by patients at the time of the baseline HbA_{1c} measure was dichotomized into 1 or ≥ 2 OGLA and subset analyses were performed subsequent to assessment of interaction. Logistic model assumptions were assessed with Hosmer and Lemeshow goodness of fit. Statistical analyses were performed using SPSS (Release 15.0.1) and STATA (Release 10), and a two-tailed alpha of 0.05 denoted statistical significance.

Results

Enrolled participants ($n=526$) had a mean $\pm$ sd age of 55.5 ± 7.3 years, were predominantly female (67%), black (62%), married (61%), full-time workers (74%), and born outside the United States (77%) (Table 1). Being female, older, and having diabetes >10 years were significantly associated with greater adherence by MPR tertile. The % with poor adherence according to the Morisky Scale and SDSCA medication question were significantly associated with lower MPR tertile. A non-significant ($p=0.13$) inverse trend was observed for HbA_{1c} across MPR tertiles. Of seven types of OGLA, the largest proportions of participants were dispensed biguanides (63%), sulfonylureas (47%), thiazolidinediones (47%), and combination tablets (35%). Meglitinides (6.5%), alpha-glucosidase inhibitors (2.9%), and sitagliptin (0.8%) constituted the rest. The sum is $>100\%$ because about half took ≥ 2 OGLA during the year.

Spearman correlations of MPR with the 4-item Morisky scale and the SDSCA medication adherence item were strongly significant (both: $\rho = 0.21$, $p < 0.001$) (not shown). MPRs using gaps alternately of 120 or 270 consecutive days to denote planned cessation of medication had marginally lower correlations with the Morisky scale that were nonetheless statistically significant ($\rho = 0.15$ and 0.17 respectively, both $p < 0.001$). Similarly, MPR based on a mean across drug classes had a correlation with Morisky scale ($\rho = 0.21$), similar to minimum MPR ($\rho = 0.20$) and MPR ignoring drug class differences ($\rho = 0.18$). Among those whose MPR was an average of MPRs from more than 1 OGLA, 40% of participants had a maximum MPR 0.85 whereas 70% of participants had a minimum MPR < 0.50 . For these participants, mean MPR had a range of $0.53 \pm .29$ to $0.60 \pm .35$ and did not differ significantly between OGLA classes ($p = 0.34$). Since the mean MPR across drug classes without accounting for terminal gaps was marginally better and conceptually simpler than its alternatives, we chose this version of MPR for all subsequent MPR analyses.

When comparing adherence classification by MPR with Morisky score, 60.8% had the same classification by both methods (15.4% had both low and 45.4% both not low). Discordant classifications were seen with 17.8% showing low adherence by MPR but not Morisky score, and 21.5% with the reverse. Medians of HbA_{1c} for these combinations were 8.9% for both low, 8.9% for only MPR low, 8.7% for only Morisky low, and 8.4% for neither low (p for trend 0.005) (Table 2).

Self-reported SDSCA items related to nutrition and physical activity were not significantly associated with MPR, except for a borderline significant association with following a healthy eating plan ($\rho = 0.09$, $p = 0.05$) and, inversely, with spacing out carbohydrates during the day ($\rho = -0.08$, $p = 0.09$). All other p values were > 0.25 (data not shown). Nutrition and physical activity SDSCA items were not significantly correlated with HbA_{1c}, but borderline associations were observed with following a healthy eating plan ($\rho = -0.07$, $p = 0.10$) and 30 minutes total of physical activity ($\rho = 0.07$, $p = 0.11$). All other p values were > 0.20 . Watching TV > 2 hours per day was significantly associated with HbA_{1c} ($\rho = 0.12$, $p = 0.01$).

Table 3 shows comparisons of median HbA_{1c} (with interquartile range) between categories of medication adherence as measured by MPR, Morisky scale and SDSCA. In the whole sample, median HbA_{1c} was significantly higher ($p = 0.02$) for the low tertile of MPR but not for SDSCA < 7 days. Non-adherence by Morisky scale had a non-significant trend ($p = 0.10$) towards association with median HbA_{1c}. A statistically significant interaction ($p = 0.02$) of lower MPR with taking 2 classes of OGLA was observed. Interactions with other covariates, including insulin use were tested but no other significant interactions were found. In stratified analyses, the statistically significant MPR association persisted only among those taking 2 OGLA.

Table 4 shows that similar associations of MPR with highest tertile of HbA_{1c} were observed even when adjusting for potentially confounding variables. For three models (whole group and two subgroups) odds ratios (and 95% confidence intervals and p values) are presented for each covariate. In the group as a whole, lower MPR, age, taking insulin, and TV watching were significant predictors of higher HbA_{1c}. The MPR association was strong in

the subset of those taking 2 OGLA but not in those taking only 1. In the 2 subset, no other covariates had statistically significant associations with higher HbA_{1c}. Among those taking 1 OGLA, age, insulin use, TV watching, taking hypertension medication, and Spanish language preference were statistically significant predictors of higher HbA_{1c}. In a sensitivity analysis re-running the model within strata of HbA_{1c} less than and 9.0 % using strata-specific upper tertile HbA_{1c} as outcome (8.3% and 11.23% respectively) the association of MPR with HbA_{1c} with MPR was strong in the upper HbA_{1c} stratum (p=0.007) but not apparent in the lower stratum (p=0.60).

Discussion

Since treatment with OGLA is a well established method to reduce HbA_{1c} it is reasonable to believe that inadequate medication adherence will contribute to suboptimal HbA_{1c} control. Identifying inadequate medication adherence could facilitate measures to improve adherence and subsequent control. These cross-sectional analyses of baseline data from the I DO study support the validity of MPR as a measure of medication adherence, based on the observed association of higher HbA_{1c} with lower MPR. This association was strong among those taking 2 OGLA but was not apparent among those taking only one. The association was also strong at values of HbA_{1c} 9.0 % but not at lower values. Despite significant correlation of MPR with the Morisky score and the SDSCA item for medication adherence, neither of the self-report measures was significantly associated with median HbA_{1c} although the Morisky score showed a consistent direction.

Others have previously shown self-report measures of medication adherence to be associated with glycaemic control in some populations (15), but in a population with sub-optimal control (as this one was), the Morisky score was not found to be a significant predictor of HbA_{1c} (16). Self-report may add additional variability to measurement of adherence that may reflect recall and other types of participant bias. Added variability can reduce the power to observe statistically significant associations with an objective laboratory measure of HbA_{1c}, which can lead to inconsistent results between studies. Moreover, self-report measures will not be available for non-adherent patients if they fail to make clinic visits, and valid administrative data measures, where available, could help identify patients who could be in the greatest need of targeted outreach for adherence interventions.

Our observation of a significant interaction of MPR with taking 2 OGLA was not expected. Patients may have been prescribed an additional class of medication because they were not responding to one. Since non-response could have in part been related to sporadic adherence, taking 2 classes of OGLA may for some be itself a marker for reduced adherence. The wide difference between minimum and maximum MPRs for those with MPRs based on more than one class of drug is consistent with this plausible explanation. Other patient characteristics, including taking insulin, did not significantly differ between the subgroups. Whether any of these had a role cannot be ruled out. Interestingly, taking insulin was a significant predictor of higher HbA_{1c} among those taking 1 OGLA but not among those taking 2. Taking insulin has been observed elsewhere to be associated with higher HbA_{1c} (17), and may be an example of classic indication bias, since higher HbA_{1c} values may trigger treating physicians to increase or intensify medication regimens. One

might expect such an observation to be attenuated among those taking 2 OGLA for the same reason. Further, the absence of statistical significance among those taking one OGLA cannot be interpreted that an association of MPR with HbA_{1c} does not exist. It is possible that we did not have sufficient power in the sub-group to observe a weaker association.

Another noteworthy finding is that standard measures of SDSCA for nutrition and physical activity did not predict HbA_{1c} and also seemed independent of medication adherence. Hours of TV viewing, however, seemed to be a substantial marker of higher HbA_{1c}, especially in the older group. It is possible that TV viewing may be a better marker for sedentary behaviour (18,19), but also may incorporate snacking behaviour (19).

Our analysis has several limitations. One was reliance on a self-administered dry-dot capillary measure of HbA_{1c}. This choice was made necessary by the I DO trial protocol. Although the laboratory had originally received NGSP approval, the variability of the filter paper, dry-dot method using capillary blood may be greater than for standard venous blood assays or even the fresh capillary blood measure now used in many clinics.

The entry requirement of an HbA_{1c} $\geq 7.5\%$ prevented us from examining the association of MPR with HbA_{1c} across the whole range of HbA_{1c} values that may be encountered and thus limits the generalizability of our findings. This was by design, however, since we wanted to target those having difficulty managing their diabetes and who might find it difficult due to life circumstances to come to a conventional diabetes self-management program. Thus we structured the enrollment process to avoid requiring the participants to come to a clinic for assessment. However, we did find that a significant association was not observable when HbA_{1c} values were restricted to $<9.0\%$ suggesting that it might not be observable for values lower than 7.5%.

An inherent limitation of administrative data for prescription refills is that it measures medication possession, not taking the medication. While we have no reason to suspect hoarding, we cannot rule out that possibility. Also, it is possible that some gaps in refills represent doctors' orders rather than non-adherence. We did not have access to physicians' recommendations which some others have had (20). However, dispensing may be a more realistic reflection of medication adherence than prescriptions. Using long "terminal gaps" as a marker for physician intent, did not improve the less complicated assessment of MPR that treated all gaps, regardless of length, as lack of adherence. The lack of a universally-accepted approach to use administrative pharmacy records to assess adherence is a limitation that has been noted (21). Even a universally-accepted method to calculate MPR is lacking (11). We found that a simple mean MPR across drug classes was at least as good as other approaches.

Our study does have substantial strengths. Our sample was drawn from working families from predominantly minority groups with a large proportion of immigrants. This population tends to be underrepresented in clinical studies, but suffers disproportionately from complications of type 2 diabetes. Despite subjects being at the lower end of worker incomes, their union-sponsored health plan provides complete coverage so that the ability to pay for medical visits, laboratory tests or even medications was thus not a barrier, as it can be for

others with diabetes. The extensive prescription medication coverage also makes it highly unlikely that participants renewed their medications outside the system; thus, the MPR we calculate is likely to be complete.

This is one of few studies that have medication adherence data both from objective pharmacy records and from self-report. We could not identify any other study that examined MPR, Morisky scale and the SDSCA medication item in the same sample. The strong association we observed between these measures gives us more confidence in the MPR we used as a measure of adherence. At the same time, the apparent differences in ability to predict HbA_{1c} are noteworthy. Our findings are consistent with others using variations of medication adherence measures from pharmacy claims data (22, 23, 24), but in this population with HbA_{1c} exclusively > 7.5%, the association seems to be strong only among those taking more than 1 OGLA. The unexpected finding of a statistically significant interaction of MPR with the number of OGLAs did not fundamentally alter our estimation that MPR can be a valid marker of adherence with regard to glycaemic control. It nonetheless was intriguing and needs additional investigation.

In summary, our calculated MPR values were consistent with two widely used self-report measures, the Morisky scale and the SDSCA item on medication adherence, and were somewhat better than these in predicting glycaemic control. These results suggest that a straightforward calculation of MPR from an administrative pharmacy database can be used as a reasonably valid measure of medication adherence in a sample of insured, type 2 diabetes patients and potentially could be used by health systems to identify those who might benefit from an outreach effort to improve adherence. We will use this MPR measure along with HbA_{1c} as primary outcome measures for the forthcoming analyses of follow-up data from the I DO trial.

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Abbreviations

OGLA	oral glucose-lowering agents
HbA_{1c}	glycated haemoglobin
MPR	medication possession ratio
SDSCA	Summary of Diabetes Self Care Activities

References

1. UK Prospective Diabetes Study (UKPDS) Group. Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). *Lancet*. 1998; 352:837–853. [PubMed: 9742976]

2. Cheung BMY, Ong KL, Cherny SS, Sham PC, Tso AWK, Lam KSL. Diabetes Prevalence and Therapeutic Target Achievement in the United States, 1999 to 2006. *Am J Med.* 2009;122(5):443–453.
3. Gerstein HC, Miller ME, Byington RP, Goff DC Jr, Bigger JT, Buse JB, Cushman WC, Genuth S, Ismail-Beigi F, Grimm RH Jr, Probstfield JL, Simons-Morton DG, Friedewald WT. Effects of intensive glucose lowering in type 2 diabetes. *N Engl J Med.* 2008; 358:2545–2559. [PubMed: 18539917]
4. American Diabetes Association. Nutrition Recommendations and Interventions for Diabetes: a position statement of the American Diabetes Association. *Diabetes Care.* 2007; 30:S48–S65. [PubMed: 17192379]
5. Boule NG, Haddad E, Kenny GP, Wells GA, Sigal RJ. Effects of exercise on glycemic control and body mass in type 2 diabetes mellitus: a meta-analysis of controlled clinical trials. *JAMA.* 2001; 286:1218–1227. [PubMed: 11559268]
6. Karve S, Cleves MA, Helm M, Hudson TJ, West Donna S, Martin BC. An empirical basis for standardizing adherence measures derived from administrative claims data among diabetic patients. *Medical Care.* 2008; 46:1125–1133. [PubMed: 18953222]
7. Clinical Trials.gov. [19 December 2008] Improving diabetes outcomes with activity, nutrition and medication. Available from <http://www.clinicaltrials.gov/ct2/show/NCT00179374?term=Improving+Diabetes+Outcomes++AND+Cohen&rank=1>.
8. [19 December 2008] Home Health Care Laboratory of America. Available from http://www.hhla.com/products_services_lab_in_an_envelope.html.
9. [20 December 2008] National Glycosylation Standardization Program (NGSP). Available from <http://www.ngsp.org/prog/index.html>.
10. Jeppsson J-O, Jerntorp P, Almer L-O, Persson R, Ekberg G, Sundkvist G. Capillary blood on filter paper for determination of HbA_{1c} by ion exchange chromatography. *Diabetes Care.* 1996; 19:142–145. [PubMed: 8718434]
11. Andrade SE, Kahler KH, Frech F, Chan KA. Methods for evaluation of medication adherence and persistence using automated databases. *Pharmacoepidemiology and Drug Safety.* 2006; 15:565–574. [PubMed: 16514590]
12. Vink NM, Klungel OH, Stolk RP, Denig P. Comparison of various measures for assessing medication refill adherence using prescription data. *Pharmacoepidemiology and Drug Safety.* 2008; 18:159–165. [PubMed: 19109809]
13. Toobert DJ, Hampson SE, Glasgow RE. The summary of diabetes self-care activities measure: Results from 7 studies and a revised scale. *Diabetes Care.* 2000; 23:943–950. [PubMed: 10895844]
14. Morisky DE, Green LW, Levine DM. Concurrent and predictive validity of a self-reported measure of medication adherence. *Med Care.* 1986; 24:67–74. [PubMed: 3945130]
15. Rhee MK, Slocum W, Ziemer DC, Culler SD, Cook CB, El-Kebbi IM, Gallina DL, Barnes C, Phillips LS. Patient adherence improves glycemic control. *Diabetes Educ.* 2005; 31:240–250. [PubMed: 15797853]
16. Odegard PS, Gray SL. Barriers to medication adherence in poorly controlled diabetes mellitus. *Diabetes Educ.* 2008; 34:692–697. [PubMed: 18669811]
17. Schectman JM, Nadkarni MM, Voss JD. The association between diabetes metabolic control and drug adherence in an indigent population. *Diabetes Care.* 2002; 25:1015–1021. [PubMed: 12032108]
18. Atienza AA, Yaroch AL, Masse LC, Moser RP, Hesse BW, King AC. Identifying sedentary subgroups: the National Cancer Institute's Health Information National Trends Survey. *Am J Prev Med.* 2006; 31:383–390. [PubMed: 17046409]
19. Blass EM, Anderson DR, Kirkorian HL, Pempek TA, Price I, Koleini MF. On the road to obesity: Television viewing increases intake of high-density foods. *Physiol Behav.* 2006; 88:597–604. [PubMed: 16822530]
20. Donnelly LA, Morris AD, Evans JMM, for the DARTS/MEMO collaboration. Adherence to insulin and its association with glycemic control in patients with type 2 diabetes. *Q J Medicine.* 2007; 100:345–350.

21. Hess LM, Raebel MA, Conner DA, Malone DC. Measurement of adherence in pharmacy administrative databases: a proposal for standard definitions and preferred measures. *Annals of Pharmacotherapy*. 2006; 40:1280–1288. [PubMed: 16868217]
22. Pladevall M, Williams LK, Potts LA, Divine G, Xi H, Lafata JE. Clinical outcomes and adherence to medications measured by claims data in patients with diabetes. *Diabetes Care*. 2004; 27:2800–2805. [PubMed: 15562188]
23. Adams AS, Trinacty CM, Zhang F, Kleinman K, Grant RW, Meigs JB, Soumerai SB, Ross-Degnan D. Medication adherence and racial differences in A_{1c} control. *Diabetes Care*. 2008; 31:916–921. [PubMed: 18235050]
24. Lawrence DB, Ragucci KR, Long LB, Parris BS, Helfer LA. Relationship of oral antihyperglycemic (sulfonylurea or metformin) medication adherence and hemoglobin A_{1c} goal attainment for HMO patients enrolled in a diabetes disease management program. *J Manag Care Pharm*. 2006; 12:466–471. [PubMed: 16925454]

Table 1

Participant characteristics by tertile of medication possession ratio (MPR)

Characteristic *	Tertile 1 < 42% n = 174	Tertile 2 42-65% n = 177	Tertile 3 >65% n = 175	Total n = 526	p for trend
Female (%)	60	70	71	67	.03
Race/ethnicity (%)					.55
Black	63	62	60	62	
Hispanic	23	23	22	23	
White	6	5	7	6	
Other	8	11	10	10	
Age (years)	54.7 ± 7.5	55.5 ± 6.7	56.4 ± 7.6	55.5 ± 7.3	.03
Married (%)	63	62	59	61	.54
Work full time (%)	72	75	75	74	.60
Income (U. S. \$) (%)					.11
<20,000	14	14	20	16	
20-29,000	28	27	25	27	
30-39,000	24	35	29	29	
40-49,000	12	7	10	10	
50,000 +	22	18	16	19	
Education (%)					.33
8 th grade	13	18	19	17	
9-11 th grade	13	9	11	11	
H.S. or GED	36	28	33	33	
Some college	22	26	24	24	
College grad	16	19	13	16	
Born outside U.S. (%) [†]	75	79	77	77	.68
Spanish preferred (%)	14	16	17	16	.48
Years with diabetes (%)					.007
<6	38	37	26	34	
6-10	34	35	34	34	
>10	28	28	40	32	
BMI (kg/m ²)	31.4 ± 6.4	31.7 ± 6.0	30.7 ± 5.9	31.2 ± 6.1	.27
TV watching >2 hours/day	44	42	38	41	.26
Taking Insulin (%)					
By self report	19	24	26	23	.11
Rx in last year	21	24	27	24	.18

Characteristic *	Tertile 1 < 42% n = 174	Tertile 2 42-65% n = 177	Tertile 3 >65% n = 175	Total n = 526	p for trend
Taking blood pressure pills	57	65	67	63	.10
Taking cholesterol pills	47	45	53	48	.33
2 OGLA	45	57	49	50	.08
HbA _{1c} %	8.9 (8.0, 10.7)	8.5 (8.0, 9.4)	8.6 (8.0, 9.9)	8.6 (8.0, 10.0)	.13
Morisky score 2	47	38	26	37	<.001
Report taking diabetes pills <7 days/ week	35	31	14	27	<.001

* Values are %, mean $\pm$ standard deviation or median (interquartile range)

[†] Born outside the U.S. does not include those born in Puerto Rico H.S., high school; GED, high school graduate equivalency; BMI, body mass index; Rx, prescription; OGLA, oral glucose-lowering agents; HbA_{1c} glycated hemoglobin

Table 2Classification of Adherence by MPR and Morisky Score with HbA_{1c}

Adherence classification	Number (%)	Median HbA _{1c}	Interquartile range
MPR low, Morisky low *	81 (15.4%)	8.9%	8.1%, 10.5%
MPR low, Morisky not low	93 (17.7%)	8.9%	8.0%, 10.9%
Morisky low, MPR not low	113 (21.5%)	8.7%	8.2%, 9.9%
MPR not low, Morisky not low	239 (45.4%)	8.4% [†]	7.9%, 9.5%
Total	526 (100%)	8.6%	8.0%. 10%

MPR, Medication Possession Ratio; HbA_{1c}, glycated hemoglobin

* MPR low: lowest MPR tertile; not low: mid and upper tertile; Morisky low: Morisky Score 2 (low adherence); not low: >2

[†] p for trend of HbA_{1c} with categories of adherence = .005

Table 3

HbA_{1c} by medication adherence categories in whole sample and stratified by number of oral glucose lowering agent classes

Medication adherence measure	Median HbA _{1c}	Interquartile range	P [*]
Total Sample			
MPR Low tertile (n=174)	8.9	(8.0, 10.7)	.02
Mid and upper tertile (n=352)	8.6	(8.0, 9.6)	
Morisky score 2 (n=194)	8.8	(8.1, 10.2)	.10
> 2 (n=332)	8.5	(7.9, 9.9)	
SDSCA: < 7 days (n=140)	8.6	(7.9, 10.2)	.52
7 days (n=386)	8.7	(8.0, 9.9)	
One oral glucose lowering agent			
MPR Low tertile (n=96)	8.6	(7.8, 10.5)	.73
Mid and upper tertile (n=178)	8.5	(8.0, 9.6)	
Morisky score 2 (n=111)	8.8	(8.1, 10.2)	.29
> 2 (n=163)	8.5	(7.9, 9.9)	
SDSCA: < 7 days (n=80)	8.5	(7.9, 9.9)	.64
7 days (n=194)	8.6	(8.0, 10.2)	
2 oral glucose lowering agents			
MPR Low tertile (n=78)	9.3	(8.2, 11.4)	.002
Mid and upper tertile (n=174)	8.6	(8.0, 9.6)	
Morisky score 2 (n=83)	8.9	(8.1, 10.1)	.23
> 2 (n=169)	8.6	(8.0, 9.9)	
SDSCA: < 7 days (n=60)	8.5	(7.8, 10.1)	.18
7 days (n=192)	8.7	(8.1, 10.0)	

HbA_{1c}, glycated haemoglobin; MPR, Medication Possession Ratio; SDSCA, Summary of Diabetes Self Care Activities Question: how many days per week taking diabetes pills as prescribed

* P values by Mann-Whitney U test

Adjusted odds ratios of highest tertile HbA_{1c}* for medication possession ratio (MPR) and covariates in whole sample and stratified by number of oral glucose lowering agents

Table 4

Variable	Whole Sample		1 oral glucose lowering agent		2 oral glucose lowering agents	
	Odds Ratio (95% CI)	P	Odds Ratio (95% CI)	P	Odds Ratio (95% CI)	P
MPR (lowest tertile vs else)	1.7 (1.2, 2.6)	.008	1.1 (0.6, 2.0)	.83	2.7 (1.5, 4.9)	.001
Age (years)	0.9 (0.9, 1.0)	<.001	0.9 (0.9, 1.0)	<.001	1.0 (0.9, 1.0)	.13
Male sex	1.2 (0.8, 1.9)	.37	1.3 (0.7, 2.4)	.47	1.1 (0.6, 2.1)	.67
Insulin use	2.1 (1.3, 3.4)	.002	3.6 (1.8, 7.2)	<.001	1.4 (0.7, 2.7)	.34
Spanish preferred	0.6 (0.3, 1.0)	.07	0.4 (0.1, 0.9)	.02	0.8 (0.3, 1.9)	.63
Foreign born	0.8 (0.5, 1.3)	.30	0.8 (0.4, 1.7)	.60	0.8 (0.4, 1.7)	.60
Income 30,000 (U.S. \$)	0.8 (0.5, 1.2)	.26	0.9 (0.5, 1.7)	.69	0.7 (0.4, 1.2)	.18
Diabetes > 10 years	1.2 (0.8, 1.9)	.36	1.0 (0.5, 2.1)	.93	1.3 (0.7, 2.3)	.40
Body mass index (kg/m ²)	1.0 (0.9, 1.0)	.09	1.0 (0.9, 1.0)	.69	1.0 (0.9, 1.0)	.14
TV > 2 hours/day	1.9 (1.2, 2.8)	.003	2.0 (1.0, 3.8)	.04	1.7 (1.0, 3.0)	.06
Taking blood pressure pills	0.8 (0.5, 1.2)	.19	0.5 (0.3, 1.0)	.03	1.1 (0.6, 2.1)	.68
Taking cholesterol pills	0.9 (0.6, 1.3)	.55	0.9 (0.5, 1.6)	.63	0.9 (0.5, 1.5)	.64
2 oral glucose lowering agents	1.1 (0.7, 1.6)	0.64	N/A	N/A	N/A	N/A

MPR, Medication possession ratio; HbA_{1c}, glycated hemoglobin

* HbA_{1c} 9.3%