



# Glucose Control and Medication Adherence Among Veterans With Diabetes and Serious Mental Illness: Does Collocation of Primary Care and Mental Health Care Matter?

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## OBJECTIVE

Persons with serious mental illness (SMI) may benefit from collocation of medical and mental health healthcare professionals and services in attending to their chronic comorbid medical conditions. We evaluated and compared glucose control and diabetes medication adherence among patients with SMI who received collocated care to those not receiving collocated care (which we call usual care).

## RESEARCH DESIGN AND METHODS

We performed a cross-sectional, observational cohort study of 363 veteran patients with type 2 diabetes and SMI who received care from one of three Veterans Affairs medical facilities: two sites that provided both collocated and usual care and one site that provided only usual care. Through a survey, laboratory tests, and medical records, we assessed patient characteristics, glucose control as measured by a current HbA<sub>1c</sub>, and adherence to diabetes medication as measured by the medication possession ration (MPR) and self-report.

## RESULTS

In the sample, the mean HbA<sub>1c</sub> was 7.4% (57 mmol/mol), the mean MPR was 80%, and 51% reported perfect adherence to their diabetes medications. In both unadjusted and adjusted analyses, there were no differences in glucose control and medication adherence by collocation of care. Patients seen in collocated care tended to have better HbA<sub>1c</sub> levels ( $\beta = -0.149$ ;  $P = 0.393$ ) and MPR values ( $\beta = 0.34$ ;  $P = 0.132$ ) and worse self-reported adherence (odds ratio 0.71;  $P = 0.143$ ), but these were not statistically significant.

## CONCLUSIONS

In a population of veterans with comorbid diabetes and SMI, patients on average had good glucose control and medication adherence regardless of where they received primary care.

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The prevalence of diabetes among individuals with serious mental illness (SMI) is estimated to be 16–25% or two to three times the rate of the average population (1,2). This increased prevalence has been noted for decades in people with SMI, notably in people with schizophrenia and other severe psychotic disorders (3). The exact cause of this relationship is unknown, but newer antipsychotic agents likely play some role (4). Regardless of the cause, diabetes and cardiovascular disease contribute significantly to the observed increased mortality and morbidity among persons with SMI (5). Within the Veterans Health Administration (VHA), the difference in the prevalence of diabetes and mortality rates between individuals with and without SMI are smaller and seem to be driven by, among other things, atherosclerosis and hypertension (6). Given that veterans with mental health needs are more likely to use the VHA for physical and mental health care than veterans without mental health needs and the high prevalence of diabetes in veteran populations (7), this creates an important subpopulation of patients with comorbid SMI and diabetes that rely heavily on the VHA for care.

Clinical care models that aim to deliver disease specific care (such as diabetes care) to veterans with SMI may improve both SMI and disease-specific healthcare outcomes. One approach is to collocate primary care healthcare professionals in mental health clinics (8). Collocation is thought to facilitate communication between healthcare professionals as well as coordination of care and has been shown to improve subjective general health for veterans with SMI (9,10). The VHA has invested heavily in collocated care, placing mental healthcare professionals in primary care clinics to help primary care healthcare professionals better manage patients with co-occurring mental illness (11); however, there has also been a move to increase the presence of primary care healthcare professionals within mental health clinics. Two recent evaluations of the VHA system have shown that when primary care healthcare professionals are collocated in the mental health clinics, veterans with SMI are more likely to receive cardiovascular risk factor evaluations and appropriate preventive care than veterans with SMI

not seen in these clinics (12,13). Another evaluation from the same group indicates that veterans seen in collocated care are also less likely to be admitted for ambulatory-sensitive admissions such as for asthma, congestive heart failure, and diabetes (14).

By overcoming barriers to care as well as coordinating care, collocation inherently embodies many of the goals of the Patient Aligned Care Teams, the Veterans Affairs (VA) medical home initiative, which aims to improve the provision of accessible, coordinated, comprehensive, patient-centered care. Determining if they also improve clinical outcomes will make it clearer for the VHA the value added from collocated care. Toward this end, we sought to determine whether receiving collocated care is associated with better diabetic outcomes in veterans with comorbid diabetes and SMI. We compared glucose control and diabetes medication adherence in veterans from three different VA medical centers, comparing outcomes in individuals with diabetes and SMI receiving collocated care to those not receiving collocated care (which we call usual care). We hypothesized that veterans with SMI and diabetes receiving collocated care would have both better glucose control and medication adherence than those not receiving collocated care.

## RESEARCH DESIGN AND METHODS

### Patients and Setting

We performed a cross-sectional, observational cohort study of patients with type 2 diabetes and SMI seeking care from three VA medical facilities: two sites provide both collocated and usual care, and one site provides only usual care. Potential participants were identified through the VHA electronic medical record. To be eligible, the potential participant had to have: a diagnosis of diabetes (any 250 ICD-9 code); received a prescription through the VHA for an antihyperglycemic medication (oral or injectable) at some time between 12 and 24 months prior to enrollment; and a diagnosis of an SMI that we defined as schizophrenia, schizophreniform disorder, schizoaffective disorder, bipolar disorder, manic affective disorder, delusional disorder, or other nonorganic psychoses (ICD-9 code: 295.0–295.99; 296.0, .1, .4, .5, .6, .7, or .8; 297.0, .1, .2, .3, .8, or

.9; and 298.0, .1, .2, .3, .4, .8, or .9). Due to potential miscoding of SMI (15), SMI was confirmed with the potential participant's mental health healthcare professional. Healthcare professionals were given an opportunity to remove patients from contact lists if they did not think it was appropriate for us to contact the patient. We then mailed potential participants a letter describing the study including a number that they could call for more information. At two sites, this was followed by a phone call, and at the third site, patients were approached by clinic staff at scheduled appointments. Recruitment procedures at the different sites varied based on what each local Institutional Review Board considered acceptable.

Interested patients met individually with a research assistant who explained the study procedures, obtained informed consent, administered a quiz assessing comprehension of the consent (16), and administered the research questionnaires asking about demographics, diabetes history, general clinical characteristics, and psychiatric symptoms and functioning. Patients who did not comprehend the consent were reimbursed for their time but not included in the study. Questions were read to patients, and responses were recorded by the research assistant. Patients held large-font, laminated cards with answer options to help them remember and select appropriate responses. Following completion of the questionnaire, the research assistant escorted participants to the clinical laboratory where they had a glycosylated hemoglobin (HbA<sub>1c</sub>) drawn. In addition, we obtained, from the medical record, the patients last documented HbA<sub>1c</sub> and date, their BMI, and pharmacy records for all antihyperglycemic, mood-stabilizing, and antipsychotic medications for the 12 months preceding the survey administration date. The Institutional Review Board at each institution approved the study protocol.

### Outcome Variables

Our outcomes of interest were glucose control as measured by the HbA<sub>1c</sub> drawn on the day of the survey administration and antihyperglycemic medication adherence as measured by the medication possession ratio (MPR) (17) over the prior year for diabetes medications

and the self-reported diabetes-specific Morisky Medication Adherence scale (18). We chose to include two measures of adherence since no single measure is considered a gold standard, and there are concerns that self-report might suffer from social desirability bias (19). We calculated a composite MPR for all antihyperglycemic medications including insulin from electronic pharmacy data for the 12 months prior to the day of the survey administration. The MPR calculates the percent of days in the past 365 in which the patient was in possession of the appropriate antihyperglycemic medications. To calculate the MPR for insulin, we used the methods developed by Kleinman et al. (20). The Morisky Medication Adherence scale includes four general questions about medication adherence without a specified timeframe. We evaluated HbA<sub>1c</sub> and MPR as continuous variables. We dichotomized self-reported adherence as perfect versus nonperfect adherence.

### Main Independent Variable of Interest

Our main independent variable of interest was receipt of collocated care (yes/no). The three study sites were chosen because each provides a different model of primary care for patients with SMI. Table 1 summarizes the differences between each site. Site 1 integrates primary care healthcare professionals into the mental health clinics. At this site, the primary care healthcare professionals deliver care in the exact same space as the mental health healthcare professionals, participate in mental health clinic conferences, and discuss comanagement of care on a routine basis. We call this model *integrated collocated care*. Site 2 collocates primary care healthcare professionals in a specialized site where a majority of the mental health care is delivered such that the

primary care healthcare professionals at this site predominantly care for veterans with mental illness. At this site, the primary care healthcare professionals are one floor above the mental health healthcare professionals, and although they only see patients who are seen in the mental health clinics, they do not formally comanage care. We call this model *specialized collocated care*. At Site 3, there is no special arrangement between primary care and the mental health services; however, as is the case in all VA medical centers, healthcare professionals use the same electronic medical record. We call this model *usual care*. While Site 1 and 2 both strive to accommodate most of their SMI patients in the collocated primary care clinics described, some SMI patients receive care from routine primary care clinics, and these patients were also designated as receiving usual care. When the study began, neither site had formal guidelines regarding who was referred to collocated care.

### Covariates

Covariates included demographic characteristics: age, sex, race, education completed, and marital status. Diabetes-specific covariates included: how long the person had diabetes; if they were prescribed oral antihyperglycemic medications, insulin, or both; the total number of diabetes medications prescribed in the previous 12 months; the number of diabetes-related comorbidities (including ophthalmologic disease, cardiovascular disease, peripheral vascular disease, cerebrovascular disease, renal disease, and complications from neuropathy); and whether they had seen an endocrinologist in the past year. Additional clinical covariates were smoking status, BMI, and a self-reported Charlson Comorbidity Index (a measure of overall

comorbidity) (21,22). Mental health covariates included the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) memory index score (an indicator of the extent of cognitive impairment) (9,23) and two subscales from the revised Behavior and Symptom Identification Scale assessing psychotic symptoms and depression (24). The RBANS memory index score is expressed as an age-adjusted standard score with a mean of ~100 and an SD of ~15. Revised Behavior and Symptom Identification Scale subscales are weighted scores based on five-point rating scales ranging from 0 to 4. Finally, we also included whether the individual received all of their care from the VHA.

### Statistical Analysis

We evaluated the unadjusted association between collocation and all covariates as well as the outcomes of interest. We used *t* tests to evaluate differences in continuous variables and  $\chi^2$  tests to evaluate differences in categorical variables. Linear regressions were used for the adjusted analysis of HbA<sub>1c</sub> and MPR, while logistic regression was used for the analysis of self-reported adherence. Because of the limited sample size and the large number of potential covariates, we performed stepped regressions, forcing collocation (yes/no) into the model to determine the association between collocation and each of the three outcomes. Covariates were retained in the final models if the association with the outcome of interest was  $P < 0.05$ . We used these same techniques to examine the associations between the type of collocation (integrated or specialized) and the outcomes of interest. All analyses used nonresponse weights that make survey responses representative of the eligible populations at each site based on available demographic and clinical characteristics. Our aim was to enroll 100 patients per group. Assuming a moderate effect in any outcome (Cohen  $d = 0.40$ ), this would provide 80% power to detect statistically significant and clinically meaningful differences between groups with a two-tailed  $\alpha = 0.05$ .

### RESULTS

We enrolled 363 individuals (212 from usual care, 151 from collocated care [89 from integrated collocated and 62 from

**Table 1—Comparison of care at different models**

	Integrated collocated	Specialized collocated	Usual care
PCHP in same clinic (with same support staff)	X		
PCHP participates in mental health clinic conferences	X		
PCHP sees mostly patients with mental health diagnoses	X	X	
Providers use the same electronic medical record	X	X	X
PCHP, primary care healthcare professional.			

specialized collated care]) out of 681 eligible participants (response rate 53%). Compared with nonparticipants, participants were more likely to be black (43 vs. 38%;  $P < 0.001$ ), have bipolar disorder (41 vs. 25%;  $P < 0.001$ ), and be younger (mean age 59 vs. 62 years;  $P < 0.001$ ); there was no difference by sex or electronic medical record–documented last HbA<sub>1c</sub>.

Overall, on average participants were 59 years old and had diabetes for 10 years (Table 2). A total of 54% had completed high school or less education, 59% were on oral diabetes medications alone, 40% had seen an endocrinologist in the past year, the mean BMI was 33, the mean psychotic symptoms score was 0.99, and the mean depression score was 1.36. Patients seen in collocated care were more likely to be black (48 vs. 35%;  $P = 0.044$ ), more likely to be a current smoker (49 vs. 44%;  $P < 0.001$ ), less likely to have seen an endocrinologist in the last year (31 vs. 46%;  $P = 0.017$ ), and had a lower RBANS score (70 vs. 76;  $P = 0.001$ ). Eighty-eight

percent of the sample was on a psychiatric medication, 70% were on an antipsychotic, 53% were on a mood-stabilizing medication, and 36% were on both. There were no differences in receipt of either class of psychiatric medication by care model.

In unadjusted analyses (Table 3), there were no glucose control or medication adherence outcome differences by collocation. The mean HbA<sub>1c</sub> was 7.4% (57 mmol/mol), the mean MPR was 80%, and 51% of the sample self-reported perfect adherence to their diabetes medications. In adjusted analyses (Table 4), patients seen in collocated care tended to have better HbA<sub>1c</sub> levels and MPR values, but this was not statistically significant at a  $P < 0.05$  level. The specific type of collocation did not alter these findings.

Results did not substantially differ when the HbA<sub>1c</sub> and MPR were dichotomized at standard VHA cut points ( $>8\%$  or  $>64$  mmol/mol for HbA<sub>1c</sub> and  $\geq 80\%$  for MPR). Similarly, the analysis of MPR did not differ substantially

when insulin was omitted from the MPR calculation.

## CONCLUSIONS

We found that in a population of veterans with comorbid SMI and diabetes, patients on average had good medication adherence ( $\geq 80\%$ ) and adequate glucose control as defined by the VHA (HbA<sub>1c</sub>  $\leq 8\%$  or  $\leq 64$  mmol/mol) regardless of where they received primary care (25). While we found a trend toward better outcomes in those receiving integrated collocated care, it was not statistically significant, possibly because outcomes were quite good even in usual care. In general, the VHA seems to be meeting VHA diabetic recommendations for their patients with both SMI and diabetes.

In this study, the mean HbA<sub>1c</sub> for all groups was 7.5% (58 mmol/mol) or less, which is on par with or better than national VHA averages (26). This value is also consistent with current VHA recommended goals for patients with diabetes (25), indicating that even in usual care,

**Table 2—Population characteristics by collocation**

	Entire sample (n = 363)	Usual care (n = 212)	Collocated care (n = 151)	P value
Age, mean (SD)	59 (7)	60 (8)	59 (7)	0.217
Male, %	95	94	97	0.116
Race, %				0.044
White	46	50	41	
Black	40	35	48	
Other	14	15	11	
Education, %				0.217
High school or less	54	51	57	
Some college	32	32	33	
College graduate	14	17	10	
Marital status				0.850
Married/living with someone	35	34	36	
Widowed	5	4	5	
Other	60	62	59	
Duration of diabetes, mean (SD)	10 (8)	10 (8)	10 (8)	0.700
Diabetes medications, %				0.513
Oral only	59	59	59	
Oral and insulin	25	23	27	
Insulin only	16	18	14	
Total diabetes medications, mean (SD)	1.73 (0.79)	1.67 (0.81)	1.82 (0.76)	0.084
$\geq 4$ diabetes complications, %	61	63	58	0.357
Endocrinologist in the past year, %	40	46	31	0.017
Current smoker, %	46	44	49	$< 0.001$
BMI, mean (SD)	33 (7)	33 (7)	32 (7)	0.424
Charlson Index, mean (SD)	3 (2)	3 (2)	3 (2)	0.609
RBANS Memory Index Score, mean (SD)	73 (18)	76 (18)	70 (17)	0.001
Psychotic symptoms, mean (SD)	0.99 (1.06)	0.92 (1.09)	1.08 (1.02)	0.290
Depressive symptoms, mean (SD)	1.36 (0.94)	1.36 (0.96)	1.37 (0.90)	0.935
All care from VA, %	55	51	61	0.081

**Table 3—Glucose control and adherence by collocation**

	Entire sample (n = 363)	Usual care (n = 212)	Collocated care (n = 151)	P value
HbA <sub>1c</sub> , mean % (range, SD)	7.4 (4.6–17.7, 1.7)	7.5 (4.6–14.1, 1.6)	7.4 (5.0–17.7, 1.9)	0.528
HbA <sub>1c</sub> , mean mmol/mol (range, SD)	57 (27–170, 18.6)	58 (27–131, 17.5)	57 (97–170, 20.8)	
MPR, mean (range, SD)	0.8 (0.0–1.0, 0.3)	0.8 (0.0–1.0, 0.3)	0.8 (0.0–1.0, 0.2)	0.134
Perfect self-reported adherence, %	51	55	45	0.070

patients with SMI are achieving diabetes goals. This may in part be because the VHA system as a whole already embodies many of the attributes specifically valued in collocated care. First, there is one electronic medical record. Thus, as long as the care is being provided within a VHA system, all records are available to every healthcare professional, and records can be flagged such that specific healthcare professionals are forced to acknowledge the content of specific notes or results. Second, even if not physically located in the same group of offices, most VA medical center clinics are located in the same building or set of buildings, and appointments, even when not collocated, can be planned for the same day without the need for additional transportation or parking. Third, while patients might not be discussed in team meetings with mental health and primary care healthcare professionals, given the proximity of providers, urgent mental health or primary care issues can be addressed by walking the patient over to the appropriate healthcare professional. Finally, with an internal encrypted e-mail

system, healthcare professionals can discuss specific patient issues without security concerns.

Another explanation that might make our results specific to the VHA includes the patient population. For the most part, the patients are all veterans and as such come from a specific culture that could make patients, especially patients with SMI, more responsive to authority figures such as medical professionals. Thus, these results may not be generalizable to a nonveteran population.

It is also interesting to note that those in usual care were more likely to have seen an endocrinologist in the past year. This may reflect the better ability of collocated healthcare professionals to address barriers to adherence in patients with SMI while usual care healthcare professionals may more frequently turn to specialists when trying to help their patients gain better control of their diabetes. Thus, while they may achieve the same results, the means may be different.

However, good diabetes control among veterans with SMI may have nothing to do with the specifics of VHA

care since even outside of the VHA, patients with and without SMI have similar control (27), and self-reported perfect adherence is almost identical to that observed in this study (18). Diabetes control in patients with SMI may have to do with the sheer numbers of appointments these patients have and the many opportunities there are to address different medical issues. Another possible explanation is patients' established experience with managing a chronic medical condition (i.e., SMI). Both of these potential explanations are consistent with literature indicating that adherence to diabetes medications in veterans with SMI is better than those without SMI and improves with visit frequency (28,29).

In contrast, our results are inconsistent with a recent national study by Kilbourne et al. (13) in which patients seen in VA medical centers with integrated collocated care were significantly more likely to have good blood pressure control but worse diabetes control. Our findings might differ because the study by Kilbourne et al. (13) did not distinguish which patients seen at centers with integrated collocated care actually received integrated collocated care, while in our analyses, we verified that patients with SMI were receiving primary care from mental health clinics.

It is also important to note that some patients had low HbA<sub>1c</sub> (<6.5%), and one had an HbA<sub>1c</sub> of 4.6%. Regardless of how low the HbA<sub>1c</sub> was on the day of the study, the mean reported years with diabetes was >5 years, and all participants had been prescribed a hypoglycemic medication (thus it is unlikely that we accidentally enrolled patients without diabetes). However, it does raise the possibility that primary care providers are not closely monitoring glucose control in their patients with SMI and that some patients may be overly aggressively taking their medication or should not be on medications at all. This in and of itself is a concern since

**Table 4—Adjusted association between care and diabetes outcomes**

	$\beta$ estimate	P value
HbA <sub>1c</sub>		
Usual care	Reference	
Any collocated care	−0.149	0.393
Integrated collocated	−0.221	0.281
Specialized collocated	−0.039	0.870
MPR		
Usual care	Reference	
Any collocated care	0.034	0.132
Integrated collocated	0.045	0.096
Specialized collocated	0.082	0.548
Self-reported adherence		
Usual care	1.0	
Any collocated care	0.71 (0.46–1.12)*	0.143
Integrated collocated	0.85 (0.50–1.43)*	0.532
Specialized collocated	0.56 (0.30–1.03)*	0.063

Variables included in models: HbA<sub>1c</sub>: education, diabetes medication type, and number of diabetes medications; MPR: race, education, marital status, number of diabetes medications, and BMI; and self-reported adherence: education, depressive symptoms, and receiving all care at the VA. \*Value is odds ratio (95% CI).



hypoglycemia can also have serious consequences (30). However, there was no indication that low HbA<sub>1c</sub> values differed whether or not the patient's care was collocated.

While large, this study has limitations. As a cross-sectional study, we can only examine associations and cannot claim causality. We included only three VA medical centers; thus, we cannot comment on all collocated care within the VHA. However, given how we collected data, we are able to assess multiple individual-level potential confounders. In addition, our findings regarding HbA<sub>1c</sub> levels are consistent with national data evaluating glucose control in patients with comorbid diabetes and SMI (31). Both sites with collocated care also had SMI patients in noncollocated usual care, making it likely that those with the most severe disease were seen in collocated care. Although we adjusted for several measures of psychiatric severity (the RBANS, psychotic symptoms, and depression symptoms), there may have been unmeasured confounding, perhaps leading us to underestimate the benefits of collocated care. While we had adequate power to detect differences between those in collocated care versus usual care, we were underpowered to detect equally large differences between the different types of collocated care and usual care. Given the direction and magnitude of the  $\beta$  estimate for integrated collocated care versus usual care, a larger sample may have found these differences statistically significant. Regardless, the entire sample exhibited adequate diabetes control and adherence. Finally, we did not measure resource use and thus cannot make any definitive statements about cost or cost-effectiveness of collocated care. Setting up collocated clinics within the VHA generally requires reallocation of providers and thus is cost-neutral to set up. Unless collocated care leads to greater resource use (such as laboratories, appointments, studies, etc.), these clinics likely place limited economic burden on the VHA but may decrease resources available to the general clinic population by diverting them to collocated clinics.

Collocated care is gaining wide favor both inside and outside of the VHA, and it achieves many of the goals set out by the VHA in its efforts to become more patient centric. Future studies should

evaluate patients' perceptions of and satisfaction with care across different models of collocation as well as other important intermediate diabetic outcomes such as blood pressure, lipid, and weight control. While we cannot say that collocated care improved diabetic outcomes, it certainly was as good as usual care for the outcomes we evaluated and was perhaps less resource intense. Examination of patients' experiences would be valuable to include in future research efforts. If collocated care improves SMI patients' experience of care, a strong argument can be made for the model.

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**Author Contributions.** J.A.L. developed the study design, obtained funding, supervised the acquisition of data, analyzed and interpreted data, and drafted the manuscript. A.W. acquired data as well as supervised the acquisition of data, organized the data analysis and interpretation, and edited the manuscript. E.L.M. performed the data analysis and edited the manuscript. S.V.E. and A.J.G. assisted with study design, acquisition of data, data analysis and interpretation, and edited the manuscript. J.K. and S.C.M. assisted with study design, data analysis and interpretation, and edited the manuscript. J.A.L. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

## References

1. Cohen D, Stolk RP, Grobbee DE, Gispen-de Wied CC. Hyperglycemia and diabetes in patients with schizophrenia or schizoaffective disorders. *Diabetes Care* 2006;29:786–791
2. Dixon L, Weiden P, Delahanty J, et al. Prevalence and correlates of diabetes in national schizophrenia samples. *Schizophr Bull* 2000;26:903–912
3. Menninger WC. The inter-relationship of mental disorder and diabetes mellitus. *J Ment Sci* 1935;81:332–357
4. Leslie DL, Rosenheck RA. Incidence of newly diagnosed diabetes attributable to atypical antipsychotic medications. *Am J Psychiatry* 2004;161:1709–1711
5. Parks J, Svendsen D, Singer P, Foti ME. Report: morbidity and mortality in people with serious mental illness [Internet], 2006. Alexandria, VA, National Association of State Mental Health Program Directors Medical Directors Council. Available from <http://www.nasmhpd.org/docs/publications/MDCdocs/Mortality%20and%20Morbidity%20Final%20Report%208.18.08.pdf>. Accessed 21 April 2014

6. Morden NE, Lai Z, Goodrich DE, et al. Eight-year trends of cardiometabolic morbidity and mortality in patients with schizophrenia. *Gen Hosp Psychiatry* 2012;34:368–379
7. Miller DR, Safford MM, Pogach LM. Who has diabetes? Best estimates of diabetes prevalence in the Department of Veterans Affairs based on computerized patient data. *Diabetes Care* 2004;27(Suppl. 2):B10–B21
8. Unützer J, Schoenbaum M, Druss BG, Katon WJ. Transforming mental health care at the interface with general medicine: report for the presidents commission. *Psychiatr Serv* 2006;57:37–47
9. Druss BG, von Esenwein SA. Improving general medical care for persons with mental and addictive disorders: systematic review. *Gen Hosp Psychiatry* 2006;28:145–153
10. Druss BG, Rohrbaugh RM, Levinson CM, Rosenheck RA. Integrated medical care for patients with serious psychiatric illness: a randomized trial. *Arch Gen Psychiatry* 2001;58:861–868
11. United States Department of Veterans Health. Mental Health Integration Home [Internet]. Available from <http://www.va.gov/PrimaryCare/mhi/index.asp>. Accessed 7 January 2013
12. Kilbourne AM, Lai Z, Bowersox N, Pirraglia P, Bauer MS. Does collocated care improve access to cardiometabolic screening for patients with serious mental illness? *Gen Hosp Psychiatry* 2011;33:634–636
13. Kilbourne AM, Pirraglia PA, Lai Z, et al. Quality of general medical care among patients with serious mental illness: does collocation of services matter? *Psychiatr Serv* 2011;62:922–928
14. Pirraglia PA, Kilbourne AM, Lai Z, Friedmann PD, O'Toole TP. Collocated general medical care and preventable hospital admissions for veterans with serious mental illness. *Psychiatr Serv* 2011;62:554–557
15. Blow FC, Zeber JE, McCarthy JF, Valenstein M, Gillon L, Bingham CR. Ethnicity and diagnostic patterns in veterans with psychoses. *Soc Psychiatry Psychiatr Epidemiol* 2004;39:841–851
16. Palmer BW, Dunn LB, Appelbaum PS, et al. Assessment of capacity to consent to research among older persons with schizophrenia, Alzheimer disease, or diabetes mellitus: comparison of a 3-item questionnaire with a comprehensive standardized capacity instrument. *Arch Gen Psychiatry* 2005;62:726–733
17. Steiner JF, Koepsell TD, Fihn SD, Inui TS. A general method of compliance assessment using centralized pharmacy records. Description and validation. *Med Care* 1988;26:814–823
18. Krapek K, King K, Warren SS, et al. Medication adherence and associated hemoglobin A1c in Type 2 diabetes. *Ann Pharmacother* 2004;38:1357–1362
19. DiMatteo MR. Variations in patients' adherence to medical recommendations: a quantitative review of 50 years of research. *Med Care* 2004;42:200–209
20. Kleinman NL, Schaneman JL, Lynch WD. The association of insulin medication possession ratio, use of insulin glargine, and health benefit costs in employees and spouses with type 2 diabetes. *J Occup Environ Med* 2008;50:1386–1393
21. Chaudhry S, Jin L, Meltzer D. Use of a self-report-generated Charlson Comorbidity Index

for predicting mortality. *Med Care* 2005;43:607–615

22. Gold JM, Queern C, Iannone VN, Buchanan RW. Repeatable battery for the assessment of neuropsychological status as a screening test in schizophrenia I: sensitivity, reliability, and validity. *Am J Psychiatry* 1999;156:1944–1950

23. Hobart MP, Goldberg R, Bartko JJ, Gold JM. Repeatable battery for the assessment of neuropsychological status as a screening test in schizophrenia, II: convergent/discriminant validity and diagnostic group comparisons. *Am J Psychiatry* 1999;156:1951–1957

24. Eisen SV, Normand S-L, Belanger AJ, Spiro A 3rd, Esch D. The revised behavior and symptom identification scale (BASIS-R): reliability and validity. *Med Care* 2004;42:1230–1241

25. VA/DoD Clinical Practice Guideline for the Management of Diabetes Mellitus in Primary Care [Internet], 2013. Available from <http://www.healthquality.va.gov/guidelines/CD/diabetes/AboutDM.asp>. Accessed 7 January 2013

26. Jackson GL, Edelman D, Weinberger M. Simultaneous control of intermediate diabetes outcomes among Veterans Affairs primary care patients. *J Gen Intern Med* 2006;21:1050–1056

27. Brown CH, Medoff D, Dickerson FB, et al. Long-term glucose control among type 2 diabetes patients with and without serious mental illness. *J Nerv Ment Dis* 2011;199:899–902

28. Kreyenbuhl J, Dixon LB, McCarthy JF, Soliman S, Ignacio RV, Valenstein M. Does adherence to medications for type 2 diabetes differ between individuals with vs without

schizophrenia? *Schizophr Bull* 2010;36:428–435

29. Kreyenbuhl J, Leith J, Medoff DR, et al. A comparison of adherence to hypoglycemic medications between Type 2 diabetes patients with and without serious mental illness. *Psychiatry Res* 2011;188:109–114

30. Gerstein HC, Miller ME, Byington RP, et al.; Action to Control Cardiovascular Risk in Diabetes Study Group. Effects of intensive glucose lowering in type 2 diabetes. *N Engl J Med* 2008;358:2545–2559

31. Krein SL, Bingham CR, McCarthy JF, Mitchinson A, Payes J, Valenstein M. Diabetes treatment among VA patients with comorbid serious mental illness. *Psychiatr Serv* 2006;57:1016–1021