Diabetes Screening among Antipsychotic-Treated Adults with Severe Mental Illness in an Integrated Delivery System: A Retrospective Cohort Study

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BACKGROUND: Severe mental illness (SMI) is associated with increased risk for type 2 diabetes, partly due to adverse metabolic effects of antipsychotic medications. In public health care settings, annual screening rates are 30%. We measured adherence to national diabetes screening guidelines for patients taking antipsychotic medications.

OBJECTIVE: To estimate diabetes screening prevalence among patients with SMI within an integrated health care system, and to assess characteristics associated with lack of screening.

DESIGN: Retrospective cohort study.

PARTICIPANTS: Antipsychotic-treated adults with SMI. We excluded participants with known diabetes.

MAIN MEASURES: Primary outcome was screening via fasting glucose test or hemoglobin A1c during a 1-year period.

KEY RESULTS: In 2014, 16,754 patients with SMI diagnoses were receiving antipsychotics. Seventy-four percent of these patients' providers ordered diabetes screening tests that year, but only 55% (9247/16,754) received screening. When the observation time frame was extended to 2 years, 73% (12,250/16,754) were screened. Adjusting for sex and race/ethnicity, young adults (aged 18–29 years) were less likely to receive screening than older age groups [adjusted RR (aRR) 1.23–1.57, $p < 0.0001$]. Compared to whites, screening was more common for Asians (aRR 1.141, 95% CI 1.089–1.195, $p < 0.0001$), less common for blacks (aRR 0.946, 95% CI 0.898–0.997, $p < 0.0375$), and no different for Hispanics (aRR 1.030, 95% CI 0.988–1.074, $p = 0.165$). Smokers were less likely to be screened than non-smokers (aRR 0.93, 95% CI 0.89–0.97, $p < 0.0008$). Utilization of either mental health or primary care services increased the likelihood of screening.

CONCLUSIONS: While almost three-fourths of adults with SMI taking antipsychotic medications received a lab order for diabetes screening, only 55% received screening within a 12-month period. Young adults and smokers were less likely to be screened, despite their disproportionate metabolic risk. Future studies should assess the barriers and facilitators with regard to diabetes screening in this vulnerable population at the patient, provider, and system levels.

KEY WORDS: diabetes screening; severe mental illness; quality of care.
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INTRODUCTION

In the United States, adults with severe mental illnesses (SMI) such as schizophrenia or bipolar disorder are estimated to die on average 25 years earlier than the general population, largely from premature cardiovascular disease (CVD).[1] SMI is associated with elevated risk for diabetes,[2] a potent risk factor for CVD. Treatment with antipsychotic medications contributes to diabetes risk, with most evidence focused on second-generation antipsychotics, although similar increases in risk are reported with older medications.[3] In 2004, the American Diabetes Association (ADA) recommended annual diabetes screening for patients treated with antipsychotics,[4] but studies indicate that only about 30% of publicly insured adults with SMI taking antipsychotics receive guideline-recommended screening.[5–7] In these settings, young adults and those without evidence of primary care utilization are less likely to be screened.[7]

The fiscal, electronic, geographic, and cultural separation between mental health care and primary care in US public health care systems creates challenges in optimizing preventive care received by this vulnerable population.[8] For instance, in the majority of US public health systems, electronic health records for people receiving primary care and mental health services are not integrated, even when these patients are receiving care in the same health care system.[9] The Affordable Care Act, coupled with recent technological advances, is

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gradually promoting the integration of electronic health information between siloed systems of care. Shared electronic health records have been proposed as a potential solution for improving diabetes care in this population.[7]

We examined screening rates among insured adults with SMI taking antipsychotic medication within Kaiser Permanente Northern California (KPNC), a large integrated delivery system providing insurance coverage and care to over four million Californians. We set out to characterize screening rates in this system and to examine whether the subgroups that were disproportionately under-screened in public health care systems[7] were similarly under-screened in a private integrated health system.

METHODS

Study Design. This retrospective cohort study utilized electronic health records from the University of California San Francisco (UCSF) Committee of Human Research and the Kaiser Permanente Northern California Institutional Review Board.

Setting. KPNC is an integrated delivery system serving over four million members in northern California. KPNC provides inpatient, outpatient, pharmacy, and laboratory services, all linked through an integrated electronic health record, under a capitated payment system, and its membership is largely representative of the California population that it serves. People with SMI are typically cared for in specialty psychiatry departments that are fully integrated within the KPNC care delivery system, with access to the full spectrum of outpatient and inpatient services. Most patients with SMI receive psychotherapeutic and case management care, in addition to medication management with a psychiatrist. For most patients, mental health services, primary care, and phlebotomy services are located within every KPNC medical facility; however, Kaiser contracts out to county community mental health clinics for intensive case management if necessary.

Population. The following inclusion criteria generated the cohort: (1) KPNC member with enrollment for at least 10 months in 2014, (2) diagnosis of SMI as defined by at least one ICD-9 diagnosis (295.xx–301.x, 307.1, 307.5, 307.51, 309.81, 311.00, 314.xx, and 317.xx–329.xx) at any point during 2012–2014, and (3) filled at least two prescriptions for an antipsychotic medication on different dates in 2014 (see eTable 1 for list of medications). Our definition of SMI used all agreed-upon diagnoses from two prior large studies (ICD 9295.xx–299.xx),[10,11] and selected "other" diagnoses where psychiatrists commonly prescribe antipsychotic medications and were used in one of those prior studies (see eTable 2). Individuals were excluded if they were younger than 18, older than 64, or had died on or before 12/31/2014. In addition, people in the KPNC diabetes registry before January 1, 2014, were excluded. This registry includes people with any known diabetes diagnosis (ICD-9 codes 250.xx and other medication parameters as previously described).[12]

Measures. The primary outcome measure was evidence of diabetes screening via fasting glucose serum (FPG) or hemoglobin A1c (a1C) test in 2014. All laboratory data in KPNC is searchable by test type to facilitate use of the data. We also assessed if these labs were ever ordered that year. The database included additional variables: age, gender, race/ethnicity, geocoded census data (including urban area type, education, and median household income census variables), psychiatric and substance abuse diagnoses, antipsychotic medications, current and past smoking status, presence or absence of prediabetes (defined by at least one laboratory FPG 100–125 mg/dL or A1c 5.7–6.4%), presence or absence of CVD (see eTable 1) and CVD risk factors, and health care utilization during both the index year (2014) and the prior year (2013). If multiple psychiatric diagnoses were documented, an individual was categorized based on a hierarchy with priority order as follows: schizophrenia and other psychotic disorders, affective disorders, autism, and other. If an individual had multiple health insurance types, they were categorized based on a hierarchy with priority order as follows: Medicaid, Medicare, commercial, and other. For example, a patient with both Medicare and commercial insurance was listed as having Medicare.

In addition to reporting the proportion of patients screened for diabetes, in order to assess the degree to which providers were following the ADA guidelines, we also examined the electronic health record to determine whether patients had a lab order for fasting glucose or hemoglobin A1c placed anytime between December 1, 2013, and December 31, 2014. We also gathered data on the person ordering the laboratory test (specialty and provider type).

Assessment of antipsychotic medication use. Since adherence challenges may represent currently unquantifiable aspects of illness severity, we examined adherence in this cohort. First, we examined the distribution of days supplied for medications with each dispensing, with the vast majority of prescriptions (70%) found to be for 30 or 100 days. As we have done previously, we also generated continuous measure of medication gaps (CMG) for this population to determine whether people were taking their medications, with gap times < 20% considered to be "adherent" to antipsychotic medications.[13] Using CMG, we found that 70% were adherent to their medications (0–19% CMG), an additional 15% were somewhat adherent (20–39% CMG), and 15% were non-adherent (40–100% CMG). The KPNC pharmacy database includes all medications prescribed by KPNC physicians and dispensed in KPNC pharmacies.

Table 1 Demographic Characteristics of Adult Kaiser Permanente Members with Severe Mental Illness Who Received Antipsychotics, by Diabetes Screening Status*

Characteristic	Total (n = 16,754)	Diabetes screening† (n = 9247)	No diabetes screening (n = 7507)	P value‡
Overall		55%	44%	–
Female gender	59%	56%	44%	0.01
Race/ethnicity				<0.001
Black	10%	51%	49%	
Asian	8%	61%	39%	
Hispanic	13%	55%	45%	
White	65%	55%	45%	
Other/unknown	2%	56%	44%	
Age, years, mean (SD)	42.4 (13.5)	44.3 (13.0)	40.0 (13.6)	<0.001
Age categories				<0.001
18–29	22%	43%	57%	
30–39	18%	52%	48%	
40–49	23%	57%	43%	
50–59	26%	62%	38%	
60–64	11%	66%	34%	
Insurance				<0.001
Medicaid	13%	54%	46%	
Medicare	22%	63%	37%	
Commercial	65%	53%	47%	
Other	<1%	68%	32%	
Psychiatric diagnosis				<0.001
Schizophrenia and other psychotic disorders	34%	57%	43%	
Affective disorders	58%	55%	45%	
Autism	2%	49%	51%	
Other severe mental illness	6%	45%	55%	
Antipsychotic medication§				0.11
Second-generation antipsychotic (SGA)	97%	55%	45%	
First-generation antipsychotic (FGA) only	3%	52%	48%	
Continuous multiple-interval measure of gaps				<0.001
< 20% (adequate adherence)	70%	58%	42%	
≥ 20% (poor adherence)	30%	48%	52%	
BMI‖				<0.001
Normal (< 25 kg/m^2)	23%	47%	53%	
Overweight (25 to < 30 kg/m^2)	23%	56%	44%	
Obese (≥ 30 kg/m^2)	31%	61%	39%	
Unknown	22%	54%	46%	
Current smoker				<0.001
Yes	20%	49%	51%	
No	61%	57%	43%	
Unknown	18%	55%	45%	
Ever smoker‖	50%	53%	47%	<0.001
Comorbid substance abuse‖¶	26%	49%	51%	<0.001
Hypertension‖¶	18%	64%	36%	<0.001
Dyslipidemia‖¶	23%	68%	32%	<0.001
CVD‖¶	6%	58%	42%	<0.001

*Column percentages are presented in the "total" column and row percentages in the "screening" columns. The percentages across rows or columns may not sum to exactly 100% because of rounding

†Defined by evidence of HgA1c or fasting glucose test in 2014, excluding people with pre-existing evidence of diabetes

‡From chi-square test comparing diabetes screening to no diabetes screening

§The American Diabetes Association recommends annual diabetes screening for anyone taking second-generation antipsychotic (SGA) medications

‖These values are from 2013

¶Diagnosis includes any of the following ICD-9 codes: Substance abuse: 303.x–305.x; hypertension: 401.x–405.x; dyslipidemia: 272.x; CVD: 402.x, 404.x, 410.x, 412.x–414.x, 427.x–431.x, 433.x–434.x, 436.x, 437.0, 437.1, 437.2, 437.8, 437.9

Assessment for missing data. To determine the completeness of our data and to ensure that screening was not occurring outside KPNC, we searched claims data for evidence of diabetes screening labs (CPT codes 82,947, 82,950, 82,951, 83,036) drawn outside of the Kaiser Permanente Northern California system. We found that less than 0.4% of laboratory tests were performed outside KPNC.

Statistical analysis. We used a directed acyclic graph (DAG) to identify confounders and mediators of each predictor of diabetes screening (see Supplemental eTable 7). We used Poisson regression to estimate covariate effects on diabetes screening for each predictor, adjusting for confounders identified by the DAG.[14] We included the patient's home medical facility as a fixed effect, which ensured that effect estimates were based solely on within-facility comparisons, thus controlling for confounding by facility-level variables. We used the same approach to estimate covariate effects on providers ordering diabetes screening tests, as well as effects on diabetes screening among the subset of patients who had laboratory tests ordered.

We conducted several additional sensitivity analyses. First, we determined whether findings were changed by extending

Table 2 Number of Outpatient visits for Adult Kaiser Permanente Members with Severe Mental Illness Who Received Antipsychotics, by Diabetes Screening Status*

Characteristic	Total (n = 16,754)	Diabetes screening† (n = 9247)	No diabetes screening (n = 7507)	P value‡
Primary care visits§				<0.001
0	17%	35%	65%	
1–2	40%	55%	45%	
3–4	21%	61%	39%	
5+	23%	66%	34%	
Mental health visits§				<0.001
0	22%	43%	57%	
1–2	30%	55%	45%	
3–4	13%	59%	41%	
5+	35%	62%	38%	
Either primary care or mental health visits§				<0.001
0	4%	17%	83%	
1–2	20%	44%	56%	
3–4	18%	55%	45%	
5+	58%	62%	38%	

**Column percentages are presented in the "total" column and row percentages in the "screening" columns. The percentages across rows or columns may not sum to exactly 100% because of rounding*
†Defined by evidence of HgA1c or fasting glucose test in 2014, excluding people with pre-existing evidence of diabetes
‡From chi-square test
§In 2014, with a maximum of one visit per day being counted within each visit category

the period of ascertainment from 1 to 2 years. We also determined whether findings changed after exclusion of individuals with "other" SMI diagnoses. A final sensitivity analysis was conducted, first excluding patients using clozapine, which prior studies[6] have shown increases diabetes screening because of mandatory blood screening, and second excluding other antipsychotics (acetophenazine, pimozide, prochlorperazine, and promazine) which are not commonly used specifically for psychotic disorders, with the result that providers may not adhere to antipsychotic screening guidelines for patients using these medications.

We also ran a simple unadjusted chi-square test for differences in proportions to compare diabetes screening between patients with SMI in this setting and an entirely different data set of individuals with SMI served by public health care.[7]

RESULTS

In 2014, 16,754 patients with SMI diagnoses were receiving antipsychotic medications. Seventy-four percent (12,401/16,754) of these patients' providers ordered diabetes screening tests that year, but only 55% (9247/16,754) of patients received diabetes screening (Table 1). When the observation time frame was extended to 2 years, 87% (14,538/16,754) of providers ordered lab tests and 73% (12,250/16,754) of patients were screened.

Tables 2 present adjusted associations with diabetes screening (n = 9247) compared to no diabetes screening (n = 7507) in 2014, dependent on various participant characteristics. Table 3 shows relative risks after adjusting for confounding variables. After adjustment for sex and race/ethnicity, young adults (aged 18–29 years) were less likely to receive screening than older groups (adjusted RR [aRR] for older ages 1.23–1.57, $p < 0.0001$). Compared to whites, screening was more common among Asians (aRR 1.14, 95% CI 1.09–1.20, $p < 0.0001$), less common among blacks (aRR 0.946, 95% CI 0.898–0.997, $p < 0.0375$), and no different among Hispanics (aRR 1.030, 95% CI 0.988–1.074, $p = 0.165$). Smokers were less likely to be screened than non-smokers (aRR 0.93, 95% CI 0.89–0.97, $p < 0.0008$). People with affective disorders (e.g., depression, bipolar disorder) were less likely to be screened than people with schizophrenia (aRR 0.94, 95% CI 0.92–0.97, $p < 0.0001$). Utilization of either mental health or primary care services increased the likelihood of receiving diabetes screening (see Tables 2 and 3). People who were overweight or obese were more likely to be screened than those of normal weight (aRR 1.13, 95% CI 1.08–1.18, $p < 0.0001$; and aRR 1.25, 95% CI 1.20–1.30, $p < 0.0001$, respectively). We also found that people with prediabetes in the prior year were more likely to be screened than those without (63.96% vs. 48.71%, $p < 0.0001$).

Overall, there were no substantial differences in the significance or direction of the predictors of diabetes screening after extending the observation period to 2 years, though the impact of each predictor was diminished (eTable 4), possibly due to delayed testing among patient groups less likely to be screened in the first year. In addition, there were no significant differences when conducting sensitivity analysis of those subjects in the "other" SMI diagnostic category or after excluding patients taking less commonly used antipsychotic medications (eTables 5 and 6).

Our unadjusted chi-square test found that patients served in this delivery setting were significantly more likely to receive screening for diabetes than Medicaid recipients served by public health care (55.19% vs. 30.08%, $p < 0.0005$).[7]

We found that diabetes screening orders were placed primarily by primary care providers (54.3%), followed by psychiatrists (38.1%) and other specialties (7.6%). The vast majority of providers ordering the tests were physicians (96.7%). We examined predictors of physician ordering of tests and found that several groups were less likely to have labs ordered: (1) young adults (aRR for older ages 1.076–1.191, $p < 0.0001$), (2) people with affective disorders (aRR 0.948, 95% CI 0.930–0.966, $p < 0.0001$), and (3) people with substance abuse disorders (aRR 0.935, 95% CI 0.914–0.956, $p < 0.0001$; Table 4). Asians were more likely than whites to have labs ordered (aRR 1.082, 95% CI 1.050–1.116, $p < 0.001$). We also examined predictors of completion of screening among those whose labs *were* ordered and found that several groups were less likely to complete screening: (1) young adults (aRR for older ages 1.145–1.316, $p < 0.0001$), (2) blacks (aRR 0.934, 95% CI 0.897–0.973,

Table 3 Potential Factors Associated with Diabetes Screening[a]

Variable	Levels	Relative risk (CI)	*P* value	Overall *P* value[k]
Gender[b]	Female vs. male	0.995 (0.981, 1.009)	0.4892	0.4892
Age categories[b]	30–39 vs. 18–29	1.232 (1.171, 1.296)	<0.0001	<0.0001
	40–49 vs. 18–29	1.358 (1.296, 1.422)	<0.0001	
	50–59 vs. 18–29	1.466 (1.402, 1.533)	<0.0001	
	60–64 vs. 18–29	1.572 (1.495, 1.653)	<0.0001	
Race/ethnicity[b]	Black vs. white	0.946 (0.898, 0.997)	0.0375	<0.0001
	Asian vs. white	1.141 (1.089, 1.195)	<0.0001	
	Hispanic vs. white	1.030 (0.988, 1.074)	0.1650	
	Other vs. white	1.044 (0.926, 1.176)	0.4824	
Insurance[c]	Medicare vs. Medicaid	1.042 (0.966, 1.124)	0.2826	0.0007
	Commercial vs. Medicaid	0.943 (0.880, 1.009)	0.0889	
	Other vs. Medicaid	1.187 (0.797, 1.766)	0.3991	
Psychiatric diagnosis[b]	Affective disorders vs. schizophrenia	0.944 (0.917, 0.973)	0.0001	<0.0001
	Autism vs. schizophrenia	1.027 (0.923, 1.142)	0.6272	
	Other SMI vs. schizophrenia	0.800 (0.746, 0.857)	<0.0001	
Substance abuse[d]	Yes vs. no	0.852 (0.823, 0.882)	<0.0001	<0.0001
Antipsychotic medications[e]	FGA vs. SGA	0.871 (0.774, 0.980)	0.0216	0.0216
Adherence to antipsychotics[f]	Poor (≥ 20%) vs. adequate (< 20%)	0.849 (0.810, 0.890)	<0.0001	<0.0001
CVD[g]	Yes vs. no	1.010 (0.954, 1.070)	0.7294	0.7294
BMI[g]	Overweight vs. normal	1.131 (1.084, 1.181)	<0.0001	<0.0001
	Obese vs. normal	1.247 (1.198, 1.297)	<0.0001	
Hypertension[g]	Yes vs. no	1.109 (1.073, 1.145)	<0.0001	<0.0001
Current smoker[h]	Yes vs. no	0.928 (0.889, 0.970)	0.0008	0.0008
Mental health utilization[i]	1–2 vs. 0	1.264 (1.209, 1.322)	<0.0001	<0.0001
	3–4 vs. 0	1.381 (1.311, 1.454)	<0.0001	
	5+ vs. 0	1.479 (1.413, 1.548)	0.0009	
Primary care utilization[j]	1–2 vs. 0	1.531 (1.450, 1.616)	<0.0001	<0.001
	3–4 vs. 0	1.686 (1.592, 1.785)	<0.0001	
	5+ vs. 0	1.819 (1.717, 1.926)	<0.0001	

[a]*Each adjusted model depends on the specific variables*
[b]*Controlling for three main demographic variables (gender, race/ethnicity, and age) and medical facility*
[c]*Controlling for three main demographic variables, urban area type, income, education, and medical facility*
[d]*Controlling for three main demographic variables, urban area type, education, psychiatric diagnosis, past mental health utilization, past primary care utilization, and medical facility*
[e]*Controlling for three main demographic variables, urban area type, education, income, insurance, psychiatric diagnosis, CVD, and medical facility*
[f]*Controlling for three main demographic variables, education, income, insurance, psychiatric diagnosis, substance abuse, past mental health utilization, and medical facility*
[g]*Controlling for three main demographic variables, urban area type, education, income, prior smoking status, psychiatric diagnosis, substance abuse, and medical facility*
[h]*Controlling for three main demographic variables, urban area type, medical facility, education, income, psychiatric diagnosis, substance abuse, CVD, past mental health utilization, and past primary care utilization. A total of 3097 MRNs (Medical Record number) with "missing" in current smoking status dropped from the model. Notably, our DAG generated three minimum sets of adjustments for current smoking. We ran all three models of adjustment for confounders and mediators for each of these predictors and found no clinically or statistically meaningful differences in the direction of the risk ratios or the statistical significance of each of the models (eTable 3). The model used here was chosen a priori based on clinical experience and prior research*
[i]*Controlling for three main demographic variables, urban area type, education, income, insurance, psychiatric diagnosis, substance abuse, current mental health utilization, past mental health utilization, adherence, and medical facility*
[j]*Controlling for three main demographic variables, urban area type, education, income, insurance, psychiatric diagnosis, psychotropic adherence, substance abuse, medical facility, CVD, current primary care utilization, current mental health utilization, past mental health utilization, and past primary care utilization. Notably, our DAG generated three minimum sets of adjustments current primary care utilization. We ran all three models of adjustment for confounders and mediators for each of these predictors and found no clinically or statistically meaningful differences in the direction of the risk ratios, or the statistical significance of each of the models (eTable 3). The model used here was chosen a priori based on clinical experience and prior research*
[k]*Tests for heterogeneity for race/ethnicity, insurance, and psychiatric diagnosis. Tests for linear trend for all other variables*

$p < 0.0011$), (3) people with substance abuse disorders (aRR 0.909, 95% CI 0.885–0.933, $p < 0.0001$), and (4) smokers (aRR 0.941, 95% CI 0.910–0.974, $p < 0.0005$). Again, Asians were more likely than whites to complete screening (aRR 1.05, 95% CI 1.02–1.09, $p < 0.0035$).

DISCUSSION

Although national guidelines recommend annual diabetes screening for all individuals taking antipsychotic medications,[4] nearly half of those with SMI in this integrated health system were not screened in 2014. This low rate of screening was significantly better, however, than a similar population served within the public health care system in the same state (55% vs. 30%, $p < 0.0005$).[7] These findings indicate challenges in meeting these guideline recommendations, even in a delivery system with a proven track record of optimizing risk control through population health interventions.[15] Given the potential value of prevention and early detection of diabetes,[16] failure to screen means missed opportunities to reduce morbidity and mortality among these high-risk individuals.

Consistent with prior findings, diabetes screening rates were particularly low for young adults with SMI.[7] Despite evidence that youth appear to be particularly susceptible to diabetes and other metabolic side effects when prescribed

Table 4 Potential Factors Associated with Ordering and Completing Diabetes Screening*

Variable	Levels	Ordering (n = 16,754)			Completing (n = 12,401)		
		Relative risk (CI)	P value	P value for trend‖	Relative risk (CI)	P value	P value for trend‖
Age categories†	30–39 vs. 18–29	1.076 (1.043, 1.110)	<0.0001	<0.0001	1.145 (1.100, 1.191)	<0.0001	<0.0001
	40–49 vs. 18–29	1.119 (1.087, 1.152)	<0.0001		1.212 (1.169, 1.257)	<0.0001	
	50–59 vs. 18–29	1.172 (1.140, 1.205)	<0.0001		1.249 (1.206, 1.294)	<0.0001	
	60–64 vs. 18–29	1.191 (1.153, 1.231)	<0.0001		1.316(1.266, 1.367)	<0.0001	
Race/ ethnicity†	Black vs. white	1.016 (0.983, 1.050)	0.3357	<0.0001	0.934 (0.897, 0.973)	0.0011	0.0002
	Asian vs. white	1.082 (1.050, 1.116)	<0.0001		1.054 (1.018, 1.092)	0.0035	
	Hispanic vs. white	1.027 (0.999, 1.056)	0.0547		1.005 (0.974, 1.038)	0.7457	
	Other vs. white	0.980 (0.898, 1.069)	0.6460		1.064 (0.979, 1.159)	0.1431	
Psychiatric diagnosis†	Affective disorders vs. schizophrenia	0.948 (0.930, 0.966)	0.0001	<0.0001	0.991 (0.969, 1.014)	0.4458	0.0959
	Autism vs. schizophrenia	0.932 (0.867, 1.001)	0.0532		1.098 (1.015, 1.188)	0.0202	
	Other SMI vs. schizophrenia	0.782 (0.743, 0.823)	<0.0001		1.010 (0.963, 1.060)	0.6836	
Substance abuse‡	Yes vs. no	0.935 (0.914, 0.956)	<0.0001	<0.0001	0.909 (0.885, 0.933)	<0.0001	<0.0001
Current smoker§	Yes vs. no	0.987 (0.960, 1.105)	0.3622	0.3622	0.941 (0.910, 0.974)	0.0005	0.0005

Each adjusted model depends on the specific variables
†Controlling for three main demographic variables (sex, race/ethnicity, and age) and medical facility
‡Controlling for three main demographic variables, county, education, psychiatric diagnosis, past mental health utilization, past primary care utilization, and medical facility
§Controlling for demographic variables (sex, race/ethnicity, age), county, education, income, CVD, past mental health utilization, past primary care utilization, psychiatric diagnosis, substance abuse, and medical facility. A total of 3097 MRNs with "missing" in current smoking status dropped from the ordering model and 2407 MRNs with "missing" in current smoking status dropped from the completing model
‖Trend P value for race/ethnicity and psychiatric diagnosis based on type 3 tests

antipsychotic medications,[17–19] diabetes screening did not appear to be prioritized in this group. It is possible that this lower screening rate among young adults with SMI is a result of clinician prioritization of other issues, as the higher relative risk associated with SGAs does not translate into a higher absolute risk. Prior studies have found that physicians often prioritize other problems facing patients with SMI over medical care,[20–22] and this may be especially likely for providers treating young adults who otherwise appear healthy. Health systems should support targeted interventions to prioritize cardiometabolic screening in young adults to improve quality of life and reduce the mortality gap.

We also observed some differences in screening rates based on race/ethnicity, with blacks with SMI being less likely to be screened than whites with SMI. This finding is similar to results reported in public health care systems, where blacks with SMI were the least likely to receive screening among all races/ethnicities.[7] It is notable that Asians were more likely to be screened than whites. This may be due to the fact that Asians—a very heterogeneous group—are at greater risk of type 2 diabetes in the general population. Future studies might examine whether this finding is due to unmeasured factors such as enhanced family support or greater health literacy. In addition, we found that people who have were significant nonadherence to their antipsychotic medications or have substance abuse problems were less likely to be screened, while those who utilize health care services more frequently are more likely to be screened.

There appeared to be risk stratification for diabetes screening among patients with SMI taking antipsychotic medications, wherein people with SMI with prediabetes, elevated weight, or comorbid cardiovascular disease risk factors were more likely to be screened for diabetes than those without these characteristics. However, smokers—arguably the population most likely to benefit from reducing coexisting cardiometabolic risk factors[23]—were less likely to be screened for diabetes than were non-smokers. This finding is consistent with a small cross-sectional study that found poor diabetes care among smokers with SMI,[24] despite the weight of evidence that smoking is a risk factor for diabetes,[25] that smokers with SMI have higher rates of cardiovascular disease than non-smokers with SMI,[26] and that smokers with diabetes have the most to gain by early intervention and diabetes control.[23]

Because of our unique ability to distinguish between clinician ordering and patient receipt of blood testing, this study also contributes to the existing literature by identifying factors predictive of screening. Most screening labs were ordered by physicians (97%) [primary care (54.3%) or psychiatry (38.1%)]. Nearly three-fourths of the SMI patients had a diabetes screening test ordered over the course of the year, and nearly half of these did not follow up to undergo testing. At the time of the study, there were automated best practice alerts to remind KPNC physicians to perform diabetes screening for individuals taking antipsychotic medications. Despite evidence of provider fatigue with automated alerts,[27] it is possible that these alerts helped to increase provider awareness and therefore explain the relatively high screening rates in this population. Nonetheless, specific vulnerable individuals were often missed: young adults and those with substance use

disorders and poor medication adherence. Administrators and health system planners might consider additional supports for physicians to maximize diabetes screening among such at-risk target populations, including direct outreach to patients and families and collaborations with pharmacists.

Since close to half of those individuals without evidence of diabetes screening *did* have orders in place, we examined predictors of screening completion and found that young adults, blacks, people with substance abuse, and smokers were less likely to complete screening even when labs were ordered, while Asians were more likely. Prior survey research has found that community psychiatrists report ordering laboratory tests but believe that patient-level factors (e.g., severity of psychiatric illness) are a major barrier to patient completion.[22] Now that diabetes screening of patients with schizophrenia taking antipsychotic medications is a HEDIS measure,[28] there is additional impetus for health systems to promote diabetes screening among all people with SMI on antipsychotic medications.

The major limitation of this study may be generalizability, since all of our data come from one delivery system, albeit a very large one. In addition, whites were overrepresented in this sample (68%) compared with the general KPNC population (43% white). This difference is consistent with prior KPNC studies,[29] and we do not believe that it should significantly influence the generalizability of the findings to more diverse populations. Our methodological requirement to include only individuals enrolled for 10 months of the year may overestimate screening rates, since the sample might include a more engaged patient population. Also, we did not differentiate whether diabetes screening rates differed based on the duration of antipsychotic therapy, since this was beyond the scope of the study.

In summary, we found that over the course of 1 year within an integrated delivery system, approximately three-fourths of adults with SMI taking antipsychotic medications received lab orders for diabetes screening, and approximately one-half underwent screening. Young adults with SMI were less likely to be screened than other age groups, despite their higher relative risk for developing metabolic side effects of antipsychotics. Future studies should try to elucidate the patient-, provider-, and organizational-level factors that may facilitate optimal diabetes screening, including following through with screening once the lab test is ordered, especially for young adults, where there is the potential to prevent early morbidity and mortality.

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