Simulated Effects of Policies to Reduce Diabetes Risk Among Adults With Schizophrenia Receiving Antipsychotics

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Objective: Second-generation antipsychotics increase the risk of diabetes and other metabolic conditions among individuals with schizophrenia. Although metabolic testing is recommended to reduce this risk, low testing rates have prompted concerns about negative health consequences and downstream medical costs. This study simulated the effect of increasing metabolic testing rates on ten-year prevalence rates of prediabetes and diabetes (diabetes conditions) and their associated health care costs.

Methods: A microsimulation model (N=21,491 beneficiaries) with a ten-year time horizon was used to quantify the impacts of policies that increased annual testing rates in a Medicaid population with schizophrenia. Data sources included California Medicaid data, National Health and Nutrition Examination Survey data, and the literature. In the model, metabolic testing increased diagnosis of diabetes conditions and diagnosis prompted prescribers to switch patients to lower-risk antipsychotics. Key inputs included observed diagnoses, prescribing rates, annual testing rates, imputed rates of undiagnosed diabetes conditions, and literature-based estimates of policy effectiveness.

Results: Compared with 2009 annual testing rates, ten-year outcomes for policies that achieved universal testing reduced exposure to higher-risk antipsychotics by 14%, time to diabetes diagnosis by 57%, and diabetes prevalence by .6%. These policies were associated with higher spending because of testing and earlier treatment.

Conclusions: The model showed that policies promoting metabolic testing provided an effective approach to improve the safety of second-generation antipsychotic prescribing in a Medicaid population with schizophrenia; however, the policies led to additional costs at ten years. Simulation studies are a useful source of information on the potential impacts of these policies.

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The rising rates of dyslipidemia, type 2 diabetes, cardiovascular disease, and other metabolic conditions in the United States constitute a major public health crisis requiring a robust and effective multistakeholder response (1,2). The risk of developing these metabolic conditions is higher for people with schizophrenia (3,4), and antipsychotic drugs, the mainstay of schizophrenia care, contribute to this excess risk. The strength of the evidence for the association between second-generation antipsychotics, the most widely used class of antipsychotics, and metabolic risk varies substantially by drug (5–12). However, the high metabolic risk associated with several of these drugs is incontrovertible (13–16).

Although several professional societies have called for the routine assessment of glucose and lipid blood levels and other indicators of metabolic health to guide prescribing of second-generation antipsychotics (17,18), antipsychotic-treated Medicaid populations are infrequently tested for metabolic abnormalities (19–21).

Because Medicaid is the most common payer for the treatment of nonelderly adults with schizophrenia (22), state Medicaid programs have a strong incentive to improve the safety of antipsychotic prescribing for this population. Although metabolic testing generates upfront costs associated with testing and treatment of conditions thus detected, metabolic testing may reduce this preventable morbidity and also reduce long-term health care costs. Therefore, efforts to increase testing rates may have important health and economic impacts.

Medicaid programs and the managed care organizations with which they contract may adopt a variety of policies (for example, pay for performance [P4P]) and other strategies (for example, academic detailing) to increase testing rates among beneficiaries with schizophrenia. Decision makers

weighing whether to adopt any such policies often have incomplete information on policy benefits and costs. Simulation models can assist with policy design and implementation by providing preliminary information on the likely impacts of policies.

We conducted a microsimulation study to provide Medicaid policy makers and other stakeholders with information on the potential effects of policies aimed at increasing metabolic testing rates among beneficiaries with schizophrenia receiving antipsychotics. Our outcomes were ten-year prevalence rates of diabetes and prediabetes, a diagnosable precursor of diabetes, and their associated health care costs. We focused on diabetes because of its high public health significance.

METHODS

Data Sources and Study Population

We used California Medicaid Analytic eXtract data for calendar years 2002–2009. California has the largest and one of the most diverse Medicaid populations, an important consideration because diabetes risk varies by race-ethnicity. We identified fee-for-service, non–dual-eligible, continuously enrolled Medicaid beneficiaries with schizophrenia diagnoses (*ICD-9* codes 295.xx) recorded in two or more outpatient claims (primary or secondary) or one or more inpatient claims during a 12-month period and observed their antipsychotic prescription fills from the date of the first schizophrenia diagnosis claim through December 31, 2008 (to allow for 12 months of data through the end of 2009; N=61,469). We excluded beneficiaries ages 0–19 and over age 65 (N=2,266) and with race-ethnicity other than black, Latino, and white, because only these categories were available in our other data sources (N=10,221).

Beneficiaries meeting the above criteria (N=48,982) contributed one to seven person-years to a panel data set containing 12-month aggregated information on antipsychotic utilization (drug and its assigned metabolic risk), metabolic testing, diabetes conditions (a term hereafter used to refer to prediabetes and diabetes), and Medicaid spending. We used this panel data set to calculate several simulation model parameter estimates (for example, transition probabilities for diagnosed diabetes and prescription drug utilization and transition rates) as described below. [Additional details are included in an online supplement to this article.]

We defined beneficiaries from the panel data set with 2002 observations as the "simulation cohort" (N=21,491) and used these beneficiaries and their 2002 demographic data and initial antipsychotic prescribing and diabetes conditions as the baseline for the microsimulation.

We assigned each person-year to one of three metabolic risk groups: high if we observed more than a 90-day cumulative supply of clozapine, olanzapine, or a low-potency first-generation antipsychotic (for example, chlorpromazine); medium if we observed more than a 90-day cumulative supply of risperidone, quetiapine, or a medium-potency first-generation antipsychotic (for example, perphenazine); and low if we observed fewer than a 90-day cumulative supply of the aforementioned antipsychotics or more than a 90-day supply of aripiprazole, ziprasidone, or a high-potency first-generation antipsychotic (for example, haloperidol) in the one-year period. Drugs were classified on the basis of the literature (for example, 13–16) and the expertise of a member of our research team (JN) to classify drugs. Because there is insufficient evidence about the impact of antipsychotic combinations on metabolic risk (for example, whether risks are additive), polypharmacy regimens were assigned the risk of the highest-risk drug in the combination. We calculated exposure with the fill date and days supplied variables. We operationalized metabolic testing as receipt of at least one lipid test and at least one glucose test during a 12-month period [see online supplement for the Current Procedural Terminology codes]. Testing rates were calculated separately for individuals with and without a diabetes diagnosis.

As in other claims-based research (20), we identified beneficiaries with diagnosed diabetes as those with one or more inpatient or two outpatient claims with a diagnosis of diabetes or complications (*ICD-9* codes 250, 357.2, 362.0, and 366.41). Claims-based diabetes diagnoses may be an underestimate of actual prevalence because of underdocumentation of diagnosed prediabetes or underdetection of both conditions. We overcame this limitation by using information on diagnosed prediabetes and undiagnosed diabetes conditions for black, Latino, or white individuals ages 20–64 available in the National Health and Nutrition Examination Survey (NHANES) data from 2007 to 2010. Because persons with schizophrenia may differ from the general population regarding both the risk of diabetes and its demographic distribution, we adjusted NHANES estimates with factors derived from the Clinical Antipsychotic Trials of Intervention Effectiveness (CATIE) (11,23) [see online supplement for details].

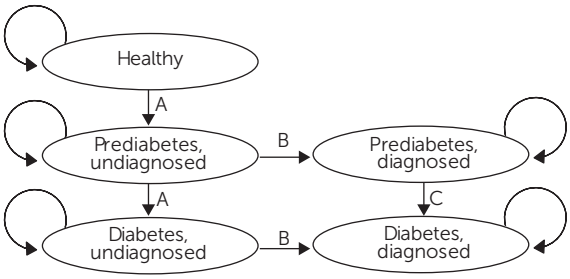
The study was approved by the RAND Institutional Review Board.

Simulation Model

We developed a microsimulation model of prescriber decision making and disease progression over a ten-year horizon. In each iteration of the model, we simulated ten annual periods starting in 2002 through 2012 for the simulation cohort.

Model inputs. Our inputs included demographic characteristics (age; sex; and white, black, or Latino race-ethnicity), rates of undiagnosed and diagnosed diabetes conditions, rates of incident diabetes conditions, antipsychotic exposure over time in the three risk categories, prior metabolic testing, prescriber decision parameters (that is, how prescribers interpret and respond to test results), and policy effectiveness. Only demographic variables, initial antipsychotic risk

FIGURE 1. Five health states of Medicaid beneficiaries in the simulation model[a]



[a] Label A, transitions between health states without diagnosis; label B, transition from undiagnosed to diagnosed states; label C, transition between prediabetes and diabetes states conditional on diagnosis. Arrows indicate that individuals can remain in the state across simulation periods (curved) or transition to other states (straight)

category, and initial rates of undiagnosed and diagnosed diabetes conditions were assessed at baseline. [Detailed descriptions of each simulation parameter are included in the online supplement.]

Because policy effectiveness varies widely depending on context (for example, type of delivery system) and program design (for example, size of incentive payments) (24,25), we let it vary from 0%, or status quo testing rates (that is, observed testing rates in the Medicaid data), to 100%, a universal-testing scenario in which every eligible patient is tested annually. Because a 20% improvement in testing rates is feasible with modest policies (for example, with P4P programs incentivizing screening [26]), the model allowed for 20% increments from the status quo to the universal-testing scenario. Readers must judge whether larger impacts are feasible in their specific context.

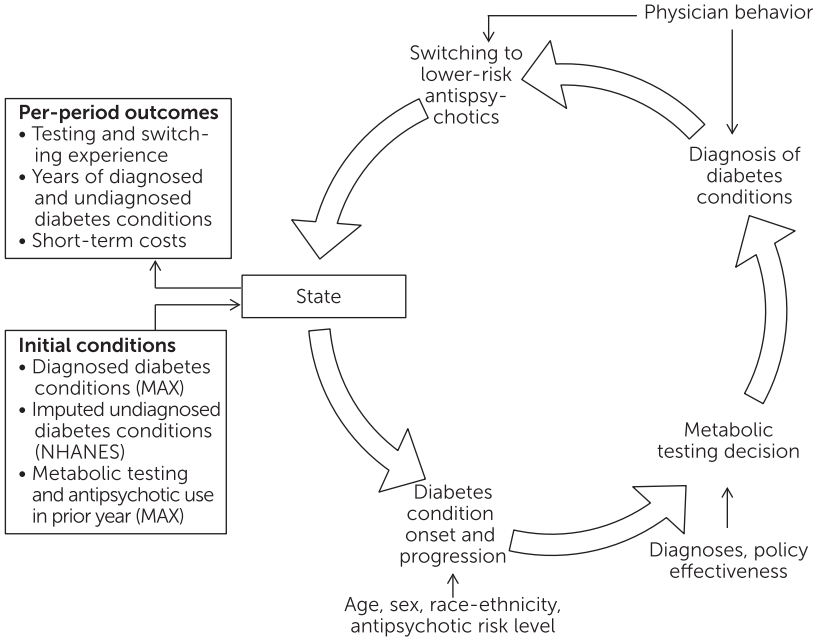
Model outcomes. Our outcomes included metabolic testing rates (the proportion of years during which individuals received metabolic testing); rate of diabetes conditions diagnosed at the end of the study's ten annual simulation periods (the proportion of diagnosed individuals relative to all individuals with diabetes conditions); years with diabetes conditions (a count of person-years with diabetes conditions regardless of diagnosis status); time to diagnosis (years from onset to diagnosis for individuals with incident diabetes conditions); and short-term costs (costs of person-level testing, and other health care costs over the ten-year period), discounted to the baseline year (2002) [see online supplement for details].

Simulation Model Framework and Evaluation

In each of the ten annual simulation periods, individuals were in one of five states: healthy (no diabetes conditions), undiagnosed prediabetes, diagnosed prediabetes, undiagnosed diabetes, or diagnosed diabetes (Figure 1). The microsimulation allowed for individuals to transition to other undiagnosed health states as described in Figure 1 but did not allow anyone to die or leave Medicaid.

We developed a set of assumptions for model inputs with insufficient empirical evidence. First, medium- and high-risk antipsychotics increase the risk of transitioning to diabetes condition states (that is, developing diabetes conditions) (27). Second, testing rates do not depend on the antipsychotic prescribed. Third, test results reveal all diabetes conditions to the prescriber without error (that is, testing causes individuals to transition from undiagnosed to diagnosed states) (Figure 1, label B). Fourth and last, test results revealing diabetes conditions lead prescribers to switch patients on medium- and high-risk drugs to a lower-risk drug 100% of the time. Although prescribers may prefer to implement an adjunctive intervention, such as metformin, over switching antipsychotics, our third assumption is supported by empirical evidence that had just began to emerge (28,29) when the most recent Schizophrenia Patient Outcomes Research Team treatment recommendations were issued (30). Two randomized controlled trials (31,32) and two reanalyses of data from the CATIE study (33,34) have provided additional supporting evidence. This evidence indicates that although a switch from higher- to lower-risk antipsychotics improves metabolic indices, a significant loss of clinical benefit is unlikely unless the drug is clozapine, thus suggesting that a switch to lower-risk drugs should be considered a first-line

FIGURE 2. Structure of the simulation model of effects of policies to reduce diabetes risk among adults with schizophrenia receiving antipsychotics[a]



[a] Data sources for initial conditions: MAX, California Medicaid Analytic eXtract, NHANES, National Health and Nutrition Examination Survey

TABLE 1. Estimates for each input in a simulation model of effects of policies to reduce diabetes risk among adults with schizophrenia receiving antipsychotics

Parameter	Estimate	Source[a]
Baseline annual metabolic testing rate	39.4%	Medicaid claims
Baseline diagnosed diabetes rate	Varies by age, sex, and race-ethnicity, mean=15.3%	Medicaid claims
Baseline undiagnosed diabetes rate	Varies by age, sex, and race-ethnicity, mean=5.6%	NHANES
Baseline diagnosed prediabetes rate	Varies by age, sex, and race-ethnicity, mean=5.2%	NHANES
Baseline undiagnosed prediabetes rate	Varies by age, sex, and race-ethnicity, mean=9.6%	NHANES
Healthy-to-prediabetes progression rate	Varies by age, sex, and race-ethnicity	NHANES
Prediabetes-to-diabetes progression rate	Varies by age, sex, and race-ethnicity	Medicaid claims
Disease progression risk multiplier for individuals on a low-risk antipsychotic compared with no antipsychotic	2×	Meyer et al., 2008 (27)
Disease progression risk multiplier for individuals on a high-risk antipsychotic compared with a low-risk antipsychotic	2×	Meyer et al., 2008 (27)
Probability of prescriber reading and accurately interpreting metabolic testing when performed	90%	Assumption, varied in sensitivity analysis
Probability of switch from high- to low-risk antipsychotic on testing and diagnosis	90%	Assumption, varied in sensitivity analysis
Annual Medicaid spending per year	Varies by age, sex, race-ethnicity, and diabetes diagnosis, mean±SD= $13,287± $16,905	Medicaid claims
Discount rate	5%	Assumption, varied in sensitivity analysis
Policy effectiveness	Varies	Range from 0% to 100% effectiveness measured by the proportion of residual, untested individuals who become tested as a result of the policy

[a] NHANES, National Health and Nutrition Examination Survey

strategy for patients who experience metabolic effects while taking nonclozapine antipsychotics. The risk-benefit analysis differs for clozapine, an underused drug in the United States (35), given its unrivaled effectiveness for treatment-resistant and suicidal presentations (30).

Figure 2 presents a graphical representation of our model.

We evaluated the simulation model in Stata 13. For our main results, we evaluated the model 1,000 times for each 20% increment in policy effectiveness.

RESULTS

Simulation Input Estimates

The simulation cohort included 21,491 beneficiaries with a mean±SD age of 43.3±10.8 years. Of the 21,491 beneficiaries, 56.3% (N=12,110) were male, 28.8% (N=4,900) were black, and 16.7% (N=3,589) were Latino. Table 1 summarizes estimates for each simulation input, which are described in greater detail below.

Prior diagnosed and undiagnosed diabetes conditions. Table 2 presents data on the distribution of individuals at baseline across the five simulation states. After imputing rates of undiagnosed and diagnosed diabetes conditions stratified by NHANES data for age, sex, and race-ethnicity, we found that 6.1% of individuals (N=1,303) in the simulation cohort had undiagnosed diabetes and 7.4% (N=1,597) had undiagnosed prediabetes in the baseline year. Older age, male sex, and black and Latino race-ethnicity were associated with higher rates of undiagnosed prediabetes and diabetes (all $p<.001$) (data not shown).

Prior metabolic testing. Overall, 39% of individuals (N=8,476) in the simulation cohort received metabolic testing in the baseline year. Testing was more likely for individuals with diagnosed versus undiagnosed diabetes (66% versus 34%, respectively, $p<.001$). Older age, female sex, and Latino ethnicity were associated with higher testing rates (all $p<.001$) (data not shown).

Simulation Outcomes

Table 3 presents data on mean outcomes for the simulation cohort across 1,000 iterations from six policy effectiveness scenarios ranging from the status quo to universal testing. All

TABLE 2. Baseline characteristics of 21,491 Medicaid beneficiaries in five health states, by level of antipsychotic risk

Antipsychotic risk and health state[a]	Percentage of simulation cohort overall[b]	Percentage of simulation cohort in risk category[b]	Source[c]
Low-risk antipsychotic	60.3	100.0	Medicaid
Healthy	38.2	63.3	—[d]
Prediabetes, diagnosed	4.6	7.6	NHANES[e]
Prediabetes, undiagnosed	4.6	7.6	NHANES
Diabetes, diagnosed	9.3	15.4	Medicaid
Diabetes, undiagnosed	3.6	6.0	NHANES
High-risk antipsychotic	39.8	100.0	Medicaid
Healthy	25.6	64.5	—[d]
Prediabetes, diagnosed	2.8	7.1	NHANES[e]
Prediabetes, undiagnosed	2.8	7.1	NHANES
Diabetes, diagnosed	6.0	15.1	Medicaid
Diabetes, undiagnosed	2.4	6.2	NHANES
Total	100	—	Medicaid

[a] Assignment to low- and high-risk antipsychotic categories was based on Medicaid prescription claims.
[b] Percentages may not sum to 100% because of rounding.
[c] NHANES, National Health and Nutrition Examination Survey
[d] Total cohort minus Medicaid diagnosed and NHANES undiagnosed populations
[e] We assumed that half of individuals with prediabetes (from NHANES) were diagnosed.

results were assessed at the end of the ten-year simulation time frame.

Receipt of metabolic testing. Individuals had on average 4.5 years with testing in the status quo and ten years with universal testing (a 120.3% increase).

High-risk antipsychotic use. High-risk antipsychotic use decreased as prescribers switched patients to lower-risk antipsychotics. High-risk antipsychotic use decreased from 5.4 years on average in the status quo to 4.6 years on average with universal testing (a 14.3% reduction).

Years with undiagnosed diabetes conditions. Individuals having at least one period with undiagnosed diabetes require testing to transition into the diagnosed diabetes state. The speed of this transition—and the initiation of diabetes treatment—depends on testing rates. In the model, individuals with diabetes remained undiagnosed for an average of 2.6 years in the status quo, compared with 1.1 years with universal testing. For individuals with prediabetes, the respective figures are 2.1 and 3.0 years. These trends reflect increased switching to lower-risk antipsychotics that resulted from more testing.

Fraction of diabetes conditions that remained undiagnosed. In the status quo, 2.4% of individuals with diabetes remained undiagnosed by the tenth year. As testing increased, the fraction of undiagnosed diabetes cases decreased to .1%. The fraction of undiagnosed prediabetes cases decreased from 16.8% (status quo) to 1.1% (universal testing).

Diabetes prevalence. There was a .6% decrease in the prevalence of diabetes by the tenth year as testing increased from the status quo to universal testing. Prediabetes rates were stable across all scenarios. This was expected because prescribers switch to lower-risk antipsychotics only after a diabetes condition has been diagnosed.

Ten-year testing and other costs. Mean per-capita Medicaid spending ranged from $83,896 in the status quo to $84,681 with universal testing. Policy scenarios of greater effectiveness contributed to higher short-term Medicaid spending largely through earlier treatment-related spending on newly diagnosed diabetes. Although overall spending was on average $712 higher with universal testing compared with the status quo, the difference in testing-related spending was only $73.

Simulation Sensitivity Analyses

Prescriber switching behavior. To account for the possibility that even when confronted with new diabetes conditions, prescribers may not switch to lower-risk drugs because of clinical considerations (for example, intolerance and clinical need for clozapine) or patient preference, we varied switch rates (data not shown). With a 50% switch rate, a higher-risk drug was received for 20% of patient-years, compared with 18% under the always-switch assumption, leading to a small (<.1%) increase in the average years spent in undiagnosed states.

Policy implementation and incentive costs. Implementation of policies to increase testing rates could—depending on the intervention and design—entail additional costs. By way of example, we modeled the costs associated with P4P and assumed a supplemental $100 incentive payment per-patient-per-year for tested patients to calculate per-capita Medicaid spending consistent with a P4P policy (data not shown). With this additional cost, per-capita spending was $694 higher on average in the universal-testing scenario.

Antipsychotic risk levels. The benefits from testing decrease if medium- and high-risk antipsychotics pose less metabolic risk than in our base case. Reducing the excess risk by 50% slightly reduced the proportion of the population with diabetes conditions at the end of the ten-year simulation (51.9% versus 50.2%) (data not shown). Beneficiaries had an average of 2.4% more years with exposure to high-risk antipsychotics and were 3.9% less likely to switch to lower-risk drugs because of a diagnosed diabetes condition.

DISCUSSION AND CONCLUSIONS

Using a microsimulation model, we found that hypothetical policies to incentivize metabolic testing have the potential to accelerate the diagnosis and reduce the prevalence of

diabetes over a ten-year time horizon. This is an important finding because diabetes, a highly prevalent chronic illness, is associated with cardiovascular complications, disability, premature mortality, and substantial health care costs (36). Although the size of the effect for some study outcomes was small—for example, a decrease of <1% in diabetes prevalence—even this small decrease may have important clinical and economic implications.

Policies that aim to reduce diabetes risk among antipsychotic-treated adults with schizophrenia by increasing testing rates must weigh implementation- and treatment-related costs relative to cost savings from preventing illness progression. We found that effective policies were associated with higher short-term costs. However, payers, patients, and the larger society might be willing to make the investment given the potential for better health outcomes. Although not assessed by our study, some of these outcomes may be evident only over a longer time horizon. These include improved cardiovascular health, improved mental health from better physical health, and improved quality of life.

Our study framed hypothetical policies in general terms rather than by specifying a particular intervention and its costs. We intentionally described our results in terms of relative policy effectiveness to increase generalizability across different strategies and health care contexts. A range of policies and other strategies may be implemented to promote safe and high-value care. These include quality improvement interventions, such as academic detailing and audit and feedback, value-based purchasing tools, value-based formulary management tools, and

TABLE 3. Outcomes of a simulation model of effects of policies to reduce diabetes risk among adults with schizophrenia receiving antipsychotics, by policy effectiveness[a]

Outcome	Policy effectiveness												δ (100% vs. 0%)[b]
	0%		20%		40%		60%		80%		100%		
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	
Years with metabolic testing	4.540	.011	5.630	.011	6.720	.011	7.820	.010	8.910	.009	10.000	.006	120.3
10-year prevalence of diabetes													
Diagnosed	.367	.003	.370	.002	.372	.002	.372	.002	.373	.002	.373	.002	1.6
Undiagnosed	.009	<.001	.005	<.001	.003	<.001	.002	<.001	.001	<.001	<.001	<.001	−88.9
Total	.376	.002	.375	.002	.374	.002	.374	.002	.374	.002	.374	.002	−.6
10-year prevalence of prediabetes													
Diagnosed	.118	.003	.128	.004	.133	.003	.137	.003	.140	.004	.142	.004	20.3
Undiagnosed	.024	.001	.016	<.001	.010	<.001	.007	<.001	.004	<.001	.002	<.001	−91.7
Total	.143	.004	.143	.004	.144	.003	.143	.003	.144	.004	.144	.004	1.5
Years of undiagnosed diabetes (among those with undiagnosed diabetes)	2.580	.050	2.050	.042	1.690	.035	1.440	.029	1.250	.027	1.106	.024	−57.1
Years of undiagnosed prediabetes (among those with undiagnosed prediabetes)	2.078	.054	2.380	.054	2.610	.054	2.780	.054	2.920	.056	3.020	.054	45.3
Years of high-risk antipsychotic use	5.424	.019	5.139	.020	4.951	.020	4.820	.020	4.723	.021	4.650	.021	−14.3
10-year per capita Medicaid costs	$83,896	$1,037	$84,100	$1,004	$84,245	$1,029	$84,404	$1,071	$85,547	$1,041	$84,681	$1,064	.9
Change in mean per capita spending versus status quo (0%) for testing	$0	—	$15	—	$29	—	$44	—	$59	—	$73	—	
Change in mean per capita spending versus status quo (0%) for all other spending	$0	—	$189	—	$319	—	$464	—	$592	—	$712	—	

[a] Values are percentages except where indicated. The model allowed for 20% increments from the status quo (0%) to the universal-testing scenario (100%). Values are means across the simulation cohort. For example, for the first row (year with metabolic testing), under the status quo assumption (0%), the simulation cohort had a mean±SD of 4.540±.011 years with metabolic testing over the ten-year period and 1,000 simulation iterations. Each individual value is significantly different from 0 ($p<.001$).

[b] Percentage change in outcomes between policies with 0% and 100% effectiveness. All differences in outcomes between the status quo (0%) and the universal-testing scenario (100%) were statistically significant ($p<.001$).

financial incentives (such as P4P). In this study, we focused on estimating the likely magnitude and direction of some of these impacts rather than on conducting a formal cost-effectiveness analysis of individual strategies. However, future research should simulate the cost-effectiveness of specific strategies implemented in specific health care settings. In this respect, it is illustrative that cost-effectiveness studies of diabetes screening in the general population suggest that screening is cost-effective among at-risk subgroups for whom costs are offset by lower future treatment costs (37).

Although antipsychotics are a critical component of schizophrenia treatment, prescribers need to consider safety as well as "hidden" medium- and long-term costs of treatment. There is consensus on the importance of monitoring metabolic indices among patients prescribed antipsychotics, as recognized by the inclusion of a diabetes screening measure for antipsychotic-treated patients in the core set of adult quality measures for Medicaid populations (38). However, despite notable efforts (39), this practice remains underused and inconsistently incentivized in Medicaid (20,21).

Several factors contribute to the underuse of metabolic testing (20). The fragmentation of the delivery and payment systems for publicly financed care of serious mental illness probably plays a key role, because the benefits of preventive interventions as well as the costs of their underuse spread over different actors and over time.

This study had some limitations. First, we relied on imputed NHANES data for undiagnosed diabetes and prediabetes prevalence rates, adjusted in aggregate to better approximate the population with schizophrenia. Although these health states are critical to decision makers who weigh the costs and benefits of policy options, they are unavailable in claims data. We were able to match rates for these conditions with the simulation cohort by using the demographic information available in the Medicaid data (including age range, sex, and race-ethnicity but not body mass index). Second, our simulations required a number of assumptions in regard to testing rates, prescriber behavior, and other parameter estimates. However, we based all assumptions on empirical evidence augmented with expert opinion provided by a member of our team (JN). Moreover, our results were robust to different assumptions, as demonstrated by our sensitivity analyses. Third, our study cohort included beneficiaries from only a single state, and thus results may not be generalizable elsewhere. Fourth, we assumed that individuals do not transition toward healthier states, although this is possible if diagnosis of a diabetes condition results in lifestyle or other changes, as a result we may have underestimated benefits from screening. Finally, because prediabetes diagnoses are inconsistently recorded in claims, we focused only on the incremental costs associated with diabetes diagnoses. As a result, we likely underestimated the total costs associated with diabetes conditions.

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REFERENCES

1. Pandya A, Gaziano TA, Weinstein MC, et al: More Americans living longer with cardiovascular disease will increase costs while lowering quality of life. Health Affairs 32:1706–1714, 2013
2. Roger VL, Go AS, Lloyd-Jones DM, et al: Heart disease and stroke statistics—2012 update: a report from the American Heart Association. Circulation 125:e2–e220, 2012
3. Colton CW, Manderscheid RW: Congruencies in increased mortality rates, years of potential life lost, and causes of death among public mental health clients in eight states. Preventing Chronic Disease 3:A42, 2006
4. Newcomer JW, Hennekens CH: Severe mental illness and risk of cardiovascular disease. JAMA 298:1794–1796, 2007
5. Allison DB, Mentore JL, Heo M, et al: Antipsychotic-induced weight gain: a comprehensive research synthesis. American Journal of Psychiatry 156:1686–1696, 1999
6. Lindenmayer J-P, Czobor P, Volavka J, et al: Changes in glucose and cholesterol levels in patients with schizophrenia treated with typical or atypical antipsychotics. American Journal of Psychiatry 160:290–296, 2003
7. Gianfrancesco F, White R, Wang RH, et al: Antipsychotic-induced type 2 diabetes: evidence from a large health plan database. Journal of Clinical Psychopharmacology 23:328–335, 2003
8. Meyer JM, Davis VG, Goff DC, et al: Change in metabolic syndrome parameters with antipsychotic treatment in the CATIE Schizophrenia Trial: prospective data from phase 1. Schizophrenia Research 101:273–286, 2008
9. Yood MU, DeLorenze G, Quesenberry CP Jr, et al: The incidence of diabetes in atypical antipsychotic users differs according to agent: results from a multisite epidemiologic study. Pharmacoepidemiology and Drug Safety 18:791–799, 2009
10. Jin H, Shih PA, Golshan S, et al: Comparison of longer-term safety and effectiveness of 4 atypical antipsychotics in patients over age 40: a trial using equipoise-stratified randomization. Journal of Clinical Psychiatry 74:10–18, 2013
11. Goff DC, Sullivan LM, McEvoy JP, et al: A comparison of ten-year cardiac risk estimates in schizophrenia patients from the CATIE study and matched controls. Schizophrenia Research 80:45–53, 2005
12. Correll CU, Frederickson AM, Kane JM, et al: Metabolic syndrome and the risk of coronary heart disease in 367 patients treated with

second-generation antipsychotic drugs. Journal of Clinical Psychiatry 67:575–583, 2006
13. Nielsen J, Skadhede S, Correll CU: Antipsychotics associated with the development of type 2 diabetes in antipsychotic-naïve schizophrenia patients. Neuropsychopharmacology 35:1997–2004, 2010
14. Newcomer JW, Haupt DW: The metabolic effects of antipsychotic medications. Canadian Journal of Psychiatry 51:480–491, 2006
15. De Hert M, Schreurs V, Sweers K, et al: Typical and atypical antipsychotics differentially affect long-term incidence rates of the metabolic syndrome in first-episode patients with schizophrenia: a retrospective chart review. Schizophrenia Research 101:295–303, 2008
16. Correll CU, Joffe BI, Rosen LM, et al: Cardiovascular and cerebrovascular risk factors and events associated with second-generation antipsychotic compared to antidepressant use in a non-elderly adult sample: results from a claims-based inception cohort study. World Psychiatry 14:56–63, 2015
17. Marder SR, Essock SM, Miller AL, et al: Physical health monitoring of patients with schizophrenia. American Journal of Psychiatry 161:1334–1349, 2004
18. American Diabetes Association, American Psychiatric Association, American Association of Clinical Endocrinologists, et al: Consensus development conference on antipsychotic drugs and obesity and diabetes. Journal of Clinical Psychiatry 65:267–272, 2004
19. Morrato EH, Druss B, Hartung DM, et al: Metabolic testing rates in 3 state Medicaid programs after FDA warnings and ADA/APA recommendations for second-generation antipsychotic drugs. Archives of General Psychiatry 67:17–24, 2010
20. Morrato EH, Campagna EJ, Brewer SE, et al: Metabolic testing for adults in a state Medicaid program receiving antipsychotics: remaining barriers to achieving population health prevention goals. JAMA Psychiatry 73:721–730, 2016
21. Mangurian C, Newcomer JW, Vittinghoff E, et al: Diabetes screening among underserved adults with severe mental illness who take antipsychotic medications. JAMA Internal Medicine 175: 1977–1979, 2015
22. Frank RG, Glied SA: Better but Not Well: Mental Health Policy in the US Since 1950. Baltimore, Johns Hopkins University Press, 2006
23. McEvoy JP, Meyer JM, Goff DC, et al: Prevalence of the metabolic syndrome in patients with schizophrenia: baseline results from the Clinical Antipsychotic Trials of Intervention Effectiveness (CATIE) schizophrenia trial and comparison with national estimates from NHANES III. Schizophrenia Research 80:19–32, 2005
24. Adams CE, Tharyan P, Coutinho ESF, et al: The schizophrenia drug-treatment paradox: pharmacological treatment based on best possible evidence may be hardest to practise in high-income countries. British Journal of Psychiatry 189:391–392, 2006
25. Rosenthal MB, Dudley RA: Pay-for-performance: will the latest payment trend improve care? JAMA 297:740–744, 2007
26. Larsen DL, Cannon W, Towner S: Longitudinal assessment of a diabetes care management system in an integrated health network. Journal of Managed Care Pharmacy 9:552–558, 2003
27. Meyer JM, Davis VG, McEvoy JP, et al: Impact of antipsychotic treatment on nonfasting triglycerides in the CATIE schizophrenia trial phase 1. Schizophrenia Research 103:104–109, 2008
28. Mukundan A, Faulkner G, Cohn T, et al: Antipsychotic switching for people with schizophrenia who have neuroleptic-induced weight or metabolic problems. Cochrane Database of Systematic Reviews 12:CD006629, 2010
29. Newcomer JW, Weiden PJ, Buchanan RW: Switching antipsychotic medications to reduce adverse event burden in schizophrenia: establishing evidence-based practice. Journal of Clinical Psychiatry 74:1108–1120, 2013
30. Buchanan RW, Kreyenbuhl J, Kelly DL, et al: The 2009 schizophrenia PORT psychopharmacological treatment recommendations and summary statements. Schizophrenia Bulletin 36:71–93, 2010
31. Newcomer JW, Campos JA, Marcus RN, et al: A multicenter, randomized, double-blind study of the effects of aripiprazole in overweight subjects with schizophrenia or schizoaffective disorder switched from olanzapine. Journal of Clinical Psychiatry 69: 1046–1056, 2008
32. Stroup TS, McEvoy JP, Ring KD, et al: A randomized trial examining the effectiveness of switching from olanzapine, quetiapine, or risperidone to aripiprazole to reduce metabolic risk: comparison of antipsychotics for metabolic problems (CAMP). American Journal of Psychiatry 168:947–956, 2011
33. Hermes E, Nasrallah H, Davis V, et al: The association between weight change and symptom reduction in the CATIE schizophrenia trial. Schizophrenia Research 128:166–170, 2011
34. Rosenheck RA, Davis S, Covell N, et al: Does switching to a new antipsychotic improve outcomes? Data from the CATIE trial. Schizophrenia Research 107:22–29, 2009
35. Stroup TS, Gerhard T, Crystal S, et al: Geographic and clinical variation in clozapine use in the United States. Psychiatric Services 65:186–192, 2014
36. Narayan K, Williams D, Gregg E, et al (eds): Diabetes Public Health: From Data to Policy. New York, Oxford University Press, 2011
37. Waugh N, Scotland G, McNamee P, et al: Screening for type 2 diabetes: literature review and economic modelling. Health Technology Assessment 11:1–125, 2007
38. Core Set of Adult Health Care Quality Measures for Medicaid (Adult Core Set): Technical Specifications and Resource Manual for Federal Fiscal Year 2015 Reporting. Baltimore, Centers for Medicare and Medicaid Services, 2015
39. Nicol G, Campagna EJ, Garfield LD, et al: The role of clinical setting and management approach in metabolic testing among youths and adults treated with antipsychotics. Psychiatric Services 67:128–132, 2016