

Outpatient Wait Time and Diabetes Care Quality Improvement

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Diabetes mellitus is a prevalent costly illness that significantly increases the risk of poor health outcomes and increased healthcare costs.¹⁻³ An essential focus of diabetes management is maintaining glycemic control.⁴ Despite accepted evidence-based guidelines and consensus in the medical community about appropriate processes of care, many patients with diabetes do not have optimal glycemic control.⁵⁻⁷

The uneven implementation of processes of care in diabetes management has led to numerous quality improvement (QI) interventions. These interventions can target patients (eg, patient education) and providers (eg, physician reminders) or can reorganize the delivery of healthcare services (eg, case management use of pharmacists to adjust medication).^{3,5-8} Evaluations of these interventions have found that they succeed at improving the process of diabetes care (eg, measuring blood glucose levels) but that the effect of these interventions on glycated hemoglobin (A1C) levels is limited.^{3,5,8}

A key to glycemic control that may be overlooked in current diabetes QI programs is the timeliness of access to care. Successful management of diabetes requires patients to consistently access care in a timely manner. For example, the progressive nature of diabetes means that glycemic control will likely deteriorate over time and that changes in glucose-lowering medication will be needed. Similarly, acute illnesses may destabilize a patient's glycemic control.^{4,9} Therefore, patients who consistently have longer wait times for appointments may have poorer glycemic control and outcomes compared with patients who have better access to healthcare services.

This study is the first to date to examine the relationship between wait time for primary care services and glycemic control in a nationwide sample by capitalizing on unique data available through the Department of Veterans Affairs (VA). Distinct from other health payers and healthcare systems, the VA automatically monitors wait times for appointments nationwide. Geographic variations in the demand for VA care or differences between VA facilities in the implementation of policies and programs aimed at managing excess demand result in varying wait times across VA facilities.¹⁰⁻¹²

We exploited this variation in wait times to examine the effect of wait time for healthcare services on glycemic control and hypothesize that patients who

Objective: To examine the relationship between glycated hemoglobin (A1C) levels and the number of days spent waiting for primary care appointments.

Study Design: Retrospective observational study that relied on Department of Veterans Affairs (VA) utilization data and Medicare claims data from 2001 to 2003. The outcome was A1C levels. The main explanatory variable of interest was facility-level primary care wait times measured in days.

Methods: Heckman selection models simultaneously predicted the presence of an A1C value and its level. Models were risk adjusted for prior individual health status. Separate models were estimated on the entire sample and on subsamples stratified by baseline A1C levels.

Results: Veterans who visited VA facilities with wait times of longer than 32.5 days had small significant increases in A1C levels of 0.14 percentage point for the whole sample, 0.07 percentage point for patients with baseline A1C levels less than 7%, 0.11 percentage point for patients with baseline A1C levels between 7% and 8%, and 0.18 percentage point for patients with baseline A1C levels greater than 8%.

Conclusions: Decreasing wait times has the potential to reduce A1C levels by 0.18 percentage point for patients with baseline A1C levels exceeding 8%. This effect is roughly one-third of what is achieved with the most successful existing quality improvement strategies. Ensuring timely access to outpatient care could be an important addition to future diabetes care quality improvement programs.

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Take-Away Points

Diabetes care quality improvement strategies have had limited success in lowering glycosylated hemoglobin (A1C) levels, with annual decreases of 0.50 percentage point in A1C levels considered successful. An overlooked element in quality improvement is timely access to healthcare.

- This study finds that longer wait times for primary care are associated with small increases in A1C levels (0.18 percentage point for patients with poor baseline control).
- The size of the effect from wait times is roughly one-third of the effect found for the most successful quality improvement strategies.
- Healthcare managers should consider adding to quality improvement programs tested interventions that ensure timely access to care.

visit VA facilities with longer wait times may have poorer glycaemic control.

METHODS

Study Population

This study used administrative data from the VA and from Medicare. The sample was extracted from the VA Diabetes Epidemiology Cohorts database, a registry of all VA patients nationwide with diabetes mellitus since 1998. The criteria for identifying patients with diabetes included a prescription for diabetes medication in the current year or at least 2 diabetes codes for inpatient or outpatient visits (VA and Medicare) over a 2-year period.¹³

Our sample consisted of veterans diagnosed as having diabetes before 2001. Outcomes were measured in 2002 and 2003, with 2001 used as a baseline year for risk adjustment (see “Data Availability” section in [Appendix A](#)). American Diabetes Association¹⁴ guidelines at the time of the study called for A1C levels to be tested biannually for individuals with glycemic control and quarterly for individuals without glycemic control. We split the outcome period into the following 4 six-month observation periods: (1) the first half of 2002, (2) the second half of 2002, (3) the first half of 2003, and (4) the second half of 2003.

To ensure complete utilization, laboratory, and diagnosis data, we required the sample to be VA users and Medicare eligible. The most important criterion for entering the sample was that individuals relied exclusively on the VA for outpatient physician visits in 2001. Following methods developed by Gardner et al, we counted outpatient physician visits in comparable ways among the VA utilization and Medicare claims data.¹⁵ Veterans who had VA outpatient physician visits and no Medicare physician visits in the baseline year were eligible for the sample. We confirmed that these individuals continued to rely heavily on the VA during the outcome period ([Table 1](#)). This was important because we needed complete A1C laboratory values, and Medicare claims do not provide laboratory values.¹⁶ A second criterion for entering

the sample was whether we had complete claims data for baseline risk adjustment. Ineligible individuals included those without baseline A1C levels for stratification or those enrolled in Medicare health maintenance organizations in 2001 (incomplete diagnosis codes for risk adjustment).

We further excluded individuals who died during the outcome period (because of changes in A1C levels right before death), individuals with missing race/ethnicity data, and individuals in a hospital or nursing home during the entire outcome period. The final sample size totaled 84,244 individuals ([Table 2](#)).

Wait Time Measure

The main explanatory variable of interest was the mean wait time until the next available primary care appointment for patients new to the primary care clinic at a VA facility. This was an overall measure of congestion at the facility, as VA managers assume that almost all new patients want the next available appointment.¹⁷

Previous studies^{18,19} demonstrated that wait times based on services that an individual actually used are inappropriate for studying the effect of wait times on outcomes. Unobserved individual health status affects individual wait times and outcomes because sicker patients are triaged to receive care faster.

Because we cannot use the individual wait time, we use a proxy measure. Our measure is a facility-level mean wait time that is exogenous to the individual and is similar to a measure used in previous research.^{18,19} Each individual’s zip code was obtained from the Medicare denominator file in 2002 and 2003 and was used to assign him or her to the nearest VA facility. All individuals who were closest to the same VA facility were assigned the same exogenous wait time corresponding to that facility. The limitations of relying on this proxy wait time measure, including the possibility of biasing results toward the null, are considered in the “Discussion” section.

Facility and Seasonal Fixed Effects

A key aspect of our study design was to include dummy variables (fixed effects) for each facility in the models. The facility fixed-effects specification removed between-facility variation in wait times and outcomes, alleviating concerns about case-mix differences across facilities and controlling for time-invariant facility quality.

The remaining variation in wait times and outcomes came from within-facility changes over time, so individual patients served as their own controls. In effect, we compared the A1C

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■ Table 1. Descriptive Demographic and Comorbidity Statistics, Stratified by Baseline A1C Level

Demographic	Baseline A1C Level			Total Sample (N = 84,244)
	<7% (n = 35,666)	7%-8% (n = 23,049)	>8% (n = 25,529)	
Age, mean (SD), y	69.6 (9.2)	69.0 (8.7)	66.2 (9.6)	68.4 (9.3)
Male sex, %	98.1	98.2	98.3	98.2
Race/ethnicity, %				
White	74.4	74.4	70.1	73.1
Black	20.9	20.6	24.3	21.8
Hispanic	2.9	2.7	3.2	2.9
Asian	0.4	0.5	0.5	0.4
Native American	0.5	0.6	0.7	0.6
Other	0.9	1.3	1.3	1.1
Baseline health status				
Diabetes Complications Severity Index, mean (SD) ^a	1.5 (1.7)	1.7 (1.7)	1.7 (1.8)	1.6 (1.7)
Congestive heart failure, %	9.0	9.5	10.8	9.7
Cardiac arrhythmia, %	9.3	9.1	8.5	9.0
Valvular disease, %	3.0	2.7	2.4	2.7
Pulmonary circulation disorder, %	0.4	0.5	0.5	0.5
Peripheral vascular disease, %	12.1	12.4	12.6	12.3
Hypertension, %	78.3	78.2	74.7	77.2
Paralysis, %	1.4	1.1	1.0	1.2
Other neurologic disorder, %	3.4	2.3	2.3	2.7
Chronic pulmonary disease, %	15.7	14.9	14.3	15.0
Hypothyroidism, %	5.3	4.7	4.3	4.8
Renal failure, %	6.3	5.5	5.0	5.7
Liver disease, %	2.0	1.4	1.7	1.7
Peptic ulcer disease, including bleeding, %	1.9	1.7	1.8	1.8
AIDS, %	0.4	0.2	0.3	0.3
Lymphoma, %	0.6	0.5	0.4	0.5
Metastatic cancer, %	0.4	0.4	0.3	0.4
Solid tumor without metastasis, %	12.6	11.5	9.6	11.4
Rheumatoid arthritis or collagen vascular disease, %	2.1	1.9	1.5	1.9
Coagulopathy, %	1.8	1.3	1.4	1.6
Obesity, %	16.7	17.5	19.3	17.7
Weight loss, %	1.5	1.0	0.9	1.2
Fluid and electrolyte disorder, %	4.0	3.6	3.9	3.9
Blood loss anemia, %	0.4	0.2	0.2	0.3
Deficiency anemia, %	9.4	7.5	6.2	7.9
Alcohol abuse, %	2.8	2.3	3.5	2.9
Drug abuse, %	1.1	1.0	1.9	1.3
Psychosis, %	10.6	8.9	11.6	10.5
Depression, %	10.6	9.9	11.2	10.6
VA access				
Priority status 1-3, %	40.1	38.4	40.2	39.6
Proportion of outpatient visits at the VA, mean (SD)	0.88 (0.22)	0.89 (0.22)	0.89 (0.21)	0.89 (0.22)
Distance to VA medical center, mean (SD), mile	35.8 (70.4)	35.8 (65.1)	35.7 (62.2)	35.7 (66.6)
Distance to VA outpatient clinic, mean (SD), mile	24.2 (21.5)	23.6 (21.6)	23.5 (21.2)	23.9 (21.4)

A1C indicates glycated hemoglobin; VA, Department of Veterans Affairs.

^aRange, 1 to 13.

■ **Table 2.** Sample Derivation

Exclusion Criterion	No. Excluded	Total Remaining
Initial sample ^a	—	89,391
Died during the outcome period	4950	84,441
Missing race/ethnicity data	99	84,342
In hospital or nursing home during entire outcome period	98	84,244

^aAn individual was eligible for the sample if he or she met the following 2 criteria: (1) relied exclusively on the Department of Veterans Affairs (VA) for outpatient services in 2001 and (2) had complete VA and Medicare claims data in 2001 for baseline risk adjustment. Noneligible individuals included those enrolled in Medicare health maintenance organizations during 2001, those having no recorded glycated hemoglobin values in 2001, and those not enrolled in Medicare in both 2002 and 2003.

level of an individual in one observation period with the A1C level of the same individual in other observation periods, which eliminated concerns about case-mix differences between facilities.

Similarly, facility fixed effects control for all aspects of facility quality that remain constant over time. For example, facilities with managerial inefficiencies may provide poor quality of care and have longer wait times. The poorer quality of care also increases the risk of poorer health outcomes independent of wait times.¹⁸ Facility fixed effects eliminated this potential confounding.^{20,21}

Finally, we included dummy variables to control for the seasonality of A1C levels and any overall increase or decrease in A1C levels over time. This statistical design, featuring a predetermined cohort of patients and time and facility fixed effects, means that any estimated relationship between wait time and A1C level was identified exclusively by within-facility variations over time that were independent of national trends.

Risk Adjustment and Other Explanatory Variables

Models were risk adjusted to control for observable differences in prior individual health status. Explanatory variables included age, sex, race/ethnicity, and diagnosis-based variables. Other explanatory variables included distance to VA care and VA priority status (1-3 vs >3). Longer driving distances have been found to be associated with poorer glycemic control,²² and veterans with a service-connected disability (priority status 1-3) receive priority access and likely experience shorter wait times.

We extracted diagnosis codes from all inpatient and outpatient encounters financed by the VA and Medicare during the 2001 baseline period and used the *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* diagnosis codes listed by Elixhauser et al²³ to define 28 comorbidity indicator variables, which included a wide variety of physical and mental conditions.

The Diabetes Complications Severity Index developed by Young et al²⁴ was used to control for diabetes severity. This index included measures of complications from retinopathy, nephropathy, neuropathy, cerebrovascular disease, cardiovascular disease, peripheral vascular disease, and metabolic disease. The ICD-9-CM codes

from VA and Medicare outpatient and inpatient utilization and claims files for 2001 were used to determine each individual's Diabetes Complications Severity Index.

Outcomes and Analyses

Data were analyzed using commercially available statistical software (STATA 10.0; StataCorp LP, College Station, TX). We modeled the mean 6-month A1C level during each observation period. The mean wait time for the previous 6 months predicted the A1C level in the current 6-month period. Therefore, each individual contributed up to 3 outcome observations because his or her first 6-month period had no lagged data available. Standard errors were clustered on individuals to account for the lack of independence between observations from the same individual.

Patients in a hospital or nursing home during the wait time measurement period should not be affected by outpatient wait times. Therefore, we censored observation periods if the veteran was in a hospital or nursing home for all 6 months during the wait time measurement period.

Despite using 6-month observation periods to maximize the availability of A1C data, 34% of A1C values during the outcome period were missing. As discussed in Appendices A and B, after considering possible imputation techniques, we treated these observations as censored using a 2-stage selection model developed by Heckman.²⁵ The first stage of the Heckman model used a probit to explain whether or not an A1C level was observed, and the second stage used linear regression analysis to explain A1C levels for observations that had recorded values. The 2 stages were jointly estimated so that the missing observations were accounted for in the second stage. This simultaneous equations approach explicitly modeled the correlation between unobservable factors in the first and second stages. The necessity of the Heckman model was confirmed with a significant Wald statistic, which tested whether this correlation was 0 and indicated that common unobservables affected both censoring and the

■ **Table 3.** First-Stage Equation Predicting the Presence of A1C Values^a

Variable	β Level	SE	P
Linear wait time, d	.0001	.0002	.75
No. of VA visits during the baseline period	.0021	.0002	<.001
Wald test of independent equations		$\chi^2 = 23,617.83$	<.001
Alternative Wait Time Specifications			
Quintile wait time, d^b			
>32.5 to ≤42.5	.0838	.0117	<.001
>42.5 to ≤51.5	.0514	.0126	<.001
>51.5 to ≤61.5	.0871	.0136	<.001
>61.5	.0523	.0155	.001
No. of VA visits in the baseline period	.0021	.0002	<.001
Wald test of independent equations		$\chi^2 = 23,640.26$	<.001
Wait time >32.5 d^b	.0774	.0112	<.001
No. of VA visits in the baseline period	.0021	.0002	<.001
Wald test of independent equations		$\chi^2 = 23,633.31$	<.001

A1C indicates glycated hemoglobin; VA, Department of Veterans Affairs.

^aAmong 84,244 persons (251,949 person-period observations). Models also include sex, race/ethnicity, Elixhauser comorbidities, seasonal effects, and VA medical center fixed effects.

^bReference 32.5 or fewer days.

outcomes (Table 3). We estimated separate Heckman models using the full sample and then stratified by baseline A1C level with a linear wait time specification, a quintile wait time specification, and a dichotomized wait time specification. Appendix C and Appendix D give complete results from both stages of the Heckman model for the dichotomized wait time specification.

We hypothesized that wait times may be more problematic for patients with diabetes who are struggling with controlling A1C levels. American Diabetes Association¹⁴ guidelines at the time of the study period stated that clinicians should aim for A1C levels less than 7% and that additional action was needed if A1C levels exceeded 8%. We stratified the sample by baseline values less than 7%, 7% to 8%, and greater than 8%.

RESULTS

Descriptive statistics for the entire sample, stratified by baseline A1C level, are given in Table 1. Similar to other samples of older VA users, our sample was predominantly male and had a high burden of physical and mental health problems. Forty percent had high-priority status for VA care. The mean proportion of outpatient visits at the VA (the number of VA visits divided by the total number of outpatient visits) was 0.89 during the outcome period, which increased our confidence that we had complete laboratory data for this sample.

Individuals with baseline A1C levels exceeding 8% were younger and had higher rates of obesity and mental health

diagnoses (eg, alcohol abuse, depression) at baseline. Other differences between groups were less systematic: the rates of physical health diagnoses varied by condition (eg, patients with A1C levels <7% had more metastasized cancer, while patients with A1C levels >8% had more congestive heart failure), and VA access variables did not differ.

The Heckman model is a 2-equation model requiring a variable that distinguishes the first equation from the second equation. In our model, this variable is the number of VA visits during baseline, which significantly increased the likelihood of observing an A1C value (Table 3). Identification of the model rests on this variable because it is excluded from the second equation.

The linear, quintile, and dichotomized specifications of wait times each revealed a significant and positive effect of wait time on A1C levels (Table 4). The quintile and dichotomized specifications suggested that the relationship was more of a step function at approximately 32.5 days as opposed to a linear relationship.

Longer wait times had a larger effect on individuals with higher baseline A1C levels (Table 5). There was a weak positive relationship between wait times and A1C levels for individuals with baseline A1C levels less than 7%. Patients with baseline A1C levels between 7% and 8% had A1C levels that were 0.11 percentage point higher when wait times at their facility were longer than 32.5 days versus when wait times were 32.5 days or less. For patients with baseline A1C levels exceeding 8%, A1C levels were 0.18 percentage point higher when wait times at their facility were longer than 32.5 days.

■ **Table 4.** Second-Stage Equation Predicting A1C Levels^a

Variable	β Level	SE	P
Linear wait time, d	.0008	.0004	.04
Alternative Wait Time Specifications			
Quintile wait time, d^b			
>32.5 to ≤42.5	.1542	.0192	<.001
>42.5 to ≤51.5	.0933	.0204	<.001
>51.5 to ≤61.5	.1514	.0221	<.001
>61.5	.1207	.0251	<.001
Wait time >32.5 d^b	.1386	.0184	<.001

A1C indicates glycated hemoglobin.

^aAmong 84,244 persons (251,949 person-period observations). Models include age, sex, race/ethnicity, Elixhauser comorbidities, seasonal effects, and Department of Veterans Affairs medical center fixed effects.

^bReference 32.5 or fewer days.

DISCUSSION

Results from this study suggest that there is an inverse relationship between the length of primary care wait time and glycemic control. The relationship seemed to be a step function, with A1C levels increased by 0.14 percentage point for the whole sample when wait times were longer than 32.5 days (Table 4). Wait times had an even larger effect on A1C levels for patients with poor glycemic control at baseline. The A1C levels were predicted to increase by 0.18 percentage point for patients who had baseline A1C levels exceeding 8% when wait times were longer than 32.5 days (Table 5). These results concur with limited previous research examining timely access to healthcare and glycemic control. Subramanian et al²⁶ found that patients with diabetes attending Indiana primary care clinics that instituted open-access scheduling (eg, same-day scheduling) decreased A1C levels by 0.12 percentage point compared with patients with diabetes using primary care clinics with traditional scheduling.

Improving A1C levels has proved to be difficult. Interventions or medications that annually decrease A1C levels by 0.50 percentage point are considered to have a clinically meaningful effect.^{7,9,10} A review of 11 different QI strategies found that 2 strategies did not significantly lower glycemic control. The following 7 strategies decreased A1C levels by less than 0.50 percentage point: patient registries, clinician education, patient education, patient reminders, promotion of self-management (eg, home glucometers), facilitated relay of clinical information outside of the existing medical record, and audit and feedback (eg, feedback to clinicians, including the percentage of patients who have achieved targeted A1C levels). Case management (eg, coordination of diagnosis and treatment) and changes in the organization of primary care (eg, routine visits with a pharmacist or nurse case manager) had the most robust improvements in glycemic control, with

decreases in A1C levels of 0.50 percentage point or more.⁷ In this study, the effect of wait times on patients with poor glycemic control is modest and roughly one-third (0.18 of 0.50) of what is considered to be a clinically meaningful effect but is similar to the effects seen with most diabetes care QI intervention strategies.

Any modest effect of wait times is further striking in the context of the VA. The reengineering of VA healthcare services since 1995 led the VA to implement policies and procedures that are equivalent to many diabetes QI interventions (eg, clinician reminders, electronic medical record, and patient education). Consequently, diabetes process of care and glycemic and lipid control are significantly better for VA patients compared with patients in many commercial managed care plans.²⁷ Therefore, even in an environment that focuses on diabetes care, timely access to care has an independent effect on glycemic control. Notably, the QI strategy associated with the biggest improvement in glycemic control (a decrease in A1C level of 0.80 percentage point) in the 2006 study by Shojania et al⁷ was a case management approach where nurse or pharmacist case managers could independently adjust medication without waiting for physician authorization. Because no single intervention has proved to be the “magic bullet” for lowering A1C levels, diabetes QI programs should consider incorporating tested interventions that focus on providing timely access to healthcare services (eg, same-day scheduling and independent medication adjustment).^{7,11,28,29} Future research should also consider whether subpopulations of patients with diabetes (such as those receiving insulin) significantly benefit from QI programs that ensure more timely access to care.

There are several important limitations of this study in addition to our not examining how wait times affect subpopulations of patients with diabetes. Most important, there are no administrative data even at the VA on how long each indi-

■ **Table 5.** Second-Stage Equation Predicting A1C Levels, Stratified by Baseline A1C Level^a

Variable	Baseline A1C Level								
	<7% (n = 35,666)			7%-8% (n = 23,049)			>8% (n = 25,529)		
	β Level	SE	P	β Level	SE	P	β Level	SE	P
Quintile wait time, d^b									
>32.5 to ≤42.5	.0790	.0218	<.001	.1235	.0290	<.001	.2061	.0379	<.001
>42.5 to ≤51.5	.0478	.0234	.04	.0851	.0305	.005	.1154	.0400	.004
>51.5 to ≤61.5	.0924	.0253	<.001	.1283	.0335	<.001	.1777	.0429	<.001
>61.5	.0869	.0284	.002	.1099	.0379	.004	.1495	.0488	.002
Wait time >32.5 d^b	.0733	.0209	<.001	.1136	.0278	<.001	.1769	.0360	<.001

A1C indicates glycated hemoglobin.

^aAmong 84,244 persons (251,949 person-period observations). Models include sex, race/ethnicity, Elixhauser comorbidities, seasonal effects, and Department of Veterans Affairs (VA) medical center fixed effects.

^bReference 32.5 or fewer days.

vidual waits for services. This data limitation, along with the lack of random variation in wait time, prevented us from conducting a traditional instrumental variables analysis. Instead, we had to construct an exogenous proxy measure of wait time. This proxy measure relies on new patients and may not correspond closely with the experiences of established patients with diabetes. Consequently, the size of the true unproxied wait time effect, along with the cutoff point of the number of days before glycemic control is affected, could be larger or smaller than our estimates.

In addition to the uncertainty introduced by the proxy measure, there are 2 reasons why the results from this study may be underestimated. Even after controlling for Elixhauser comorbidities, the stratified results come from broad groups that likely include a heterogeneous mix of patients with various unobserved health conditions. For example, patients with A1C levels exceeding 8% at baseline could include individuals with so many other pressing health problems that blood glucose is not actively being controlled. We tried to stratify the sample into smaller groups (eg, baseline A1C levels of 8% to <9% and of ≥9%), but the large amount of censoring in the data made estimates on smaller groups unstable. Furthermore, techniques to develop the exogenous wait time measure may have introduced measurement error (eg, assigning a VA facility based on distance), which would further bias the results toward the null. Finally, we acknowledge that VA facilities may not implement diabetes care consistently. Our study design controlled for this limitation by including facility-level fixed effects that control for time-invariant differences in quality.

Healthcare policy makers, health plans, payers, and clinicians continue to prioritize glycemic control among patients with diabetes to prevent long-term complications and to reduce healthcare costs.^{5,30} Results of this study point to a significant relationship between wait time for regular primary care appointments and glycemic control. For patients with poor

control at baseline, timely access to care may reduce glycemic control by 0.18 percentage point, which is roughly one-third of the effect seen for the most successful QI strategies aimed at improving diabetes care. Ensuring timely access to healthcare services may be another valuable component of QI programs that can be used to maintain glycemic control.

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■ Appendix A. Data and Analysis Details

Data Availability

Data were limited to 2001 to 2003 because of the suspension of a data-sharing agreement between the Department of Veterans Affairs and the Centers for Medicare & Medicaid Services between 2006 and the present, which limited access to Medicare data in more recent years.

Analysis Specification

Despite using 6-month observation periods to maximize the availability of glycated hemoglobin (A1C) level data, 34% of A1C values during the outcome period were missing. We originally considered 2 techniques for imputing the missing values, namely, multiple imputation and linear interpolation of missing A1C levels if valid values existed on either side of the missing value. Appendix B suggests that healthier

patients were more likely to have missing A1C levels, with a lower percentage of these patients experiencing most comorbidities. Because A1C values were not missing at random, the proposed imputation techniques were inappropriate. Missing A1C levels were likely to be systematically lower than observed values because healthier patients have lower values. If this difference was wholly accounted for by the observable variables in Appendix B, multiple imputation could be used without introducing bias. On the other hand, if unobservable factors also contributed to the difference, then imputed values would be too high, biasing the estimated relationship between wait times and A1C levels toward the null. Therefore, we dispensed of imputation techniques and treated missing observations as censored using a Heckman selection model.²⁵

■ **Appendix B. Demographic and Comorbidity Means, Stratified by Missing A1C Values**

Demographic	A1C Values in the Outcome Period	
	Missing ≥1 (n = 55,025)	None Missing (n = 29,219)
Age, mean (SD), y	68.6 (9.5)	68.1 (9.0)
Male sex, %	98.1	98.4
Race/ethnicity, %		
White	72.1	74.9
Black	23.1	19.6
Hispanic	2.7	3.3
Asian	0.4	0.5
Native American	0.6	0.5
Other	1.1	1.2
Baseline health status		
Diabetes Complications Severity Index, mean (SD) ^a	1.6 (1.7)	1.7 (1.7)
Congestive heart failure, %	9.6	9.9
Cardiac arrhythmia, %	8.8	9.3
Valvular disease, %	2.7	2.8
Pulmonary circulation disorder, %	0.4	0.5
Peripheral vascular disease, %	12.3	12.4
Hypertension, %	76.8	77.9
Paralysis, %	1.3	1.1
Other neurologic disorder, %	2.9	2.5
Chronic pulmonary disease, %	15.0	15.2
Hypothyroidism, %	4.6	5.3
Renal failure, %	5.8	5.5
Liver disease, %	1.8	1.7
Peptic ulcer disease, including bleeding, %	1.9	1.8
AIDS, %	0.3	0.3
Lymphoma, %	0.5	0.5
Metastatic cancer, %	0.4	0.4
Solid tumor without metastasis, %	11.3	11.5
Rheumatoid arthritis or collagen vascular disease, %	1.8	2.0
Coagulopathy, %	1.6	1.6
Obesity, %	17.3	18.6
Weight loss, %	1.2	1.1
Fluid and electrolyte disorder, %	3.8	3.9
Blood loss anemia, %	0.3	0.3
Deficiency anemia, %	7.9	7.8
Alcohol abuse, %	3.1	2.5
Drug abuse, %	1.5	1.0
Psychosis, %	10.5	10.4
Depression, %	10.4	10.8
VA access		
Priority status 1-3, %	38.9	41.0
Proportion of outpatient visits at VA, mean (SD)	0.87 (0.24)	0.92 (0.17)
Distance to VA medical center, mean (SD), mile	35.9 (69.5)	35.4 (60.7)
Distance to VA outpatient clinic, mean (SD), mile	23.8 (21.4)	23.9 (21.5)
VA indicates Department of Veterans Affairs.		
^a Range, 1 to 13.		

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■ Appendix C. First-Stage Equation Predicting the Presence of A1C Values^a

Variable	β Level	SE	P
Wait time >32.5 d ^b	0.0774	0.0112	<.001
No. of VA visits during the baseline period	0.0021	0.0002	<.001
Distance to VA medical center	0.0004	0.00005	<.001
Distance to VA outpatient clinic	-0.0003	0.0002	.16
Outcome period first half 2003	0.0215	0.0056	<.001
Outcome period second half 2003	-0.0407	0.0057	<.001
Age	-0.0098	0.0003	<.001
Male sex	0.0829	0.0214	<.001
White race/ethnicity ^c	-0.0207	0.0078	.008
Hispanic race/ethnicity ^c	0.0063	0.0189	.74
Asian race/ethnicity ^c	-0.0095	0.0423	.82
Native American race/ethnicity ^c	-0.1909	0.0404	<.001
Other race/ethnicity ^c	-0.0341	0.0267	.20
Priority status 1-3	0.0306	0.0059	<.001
Diabetes Complications Severity Index ^d	0.0298	0.0023	<.001
Congestive heart failure	-0.0114	0.0107	.29
Cardiac arrhythmia	-0.0083	0.0103	.42
Valvular disease	-0.0118	0.0170	.49
Pulmonary circulation disorder	0.0102	0.0426	.81
Peripheral vascular disease	-0.0321	0.0092	.001
Hypertension	0.0273	0.0068	<.001
Paralysis	-0.1713	0.0273	<.001
Other neurological disorder	-0.1065	0.0177	<.001
Chronic pulmonary disease	-0.0154	0.0078	.049
Hypothyroidism	0.0324	0.0130	.01
Renal failure	-0.1235	0.0136	<.001
Liver disease	0.0136	0.0240	.57
Peptic ulcer disease, including bleeding	0.0089	0.0208	.67
AIDS	-0.0354	0.0593	.55
Lymphoma	0.0176	0.0382	.65
Metastatic cancer	-0.0950	0.0444	.03
Solid tumor without metastasis	0.0164	0.0086	.06
Rheumatoid arthritis or collagen vascular disease	-0.0055	0.0204	.79
Coagulopathy	0.0186	0.0225	.41
Obesity	0.0390	0.0074	<.001
Weight loss	-0.0431	0.0275	.12
Fluid and electrolyte disorder	0.0015	0.0160	.93
Blood loss anemia	-0.0023	0.0528	.97
Deficiency anemia	-0.0081	0.0109	.46
Alcohol abuse	-0.0678	0.0184	<.001
Drug abuse	-0.1487	0.0292	<.001
Psychosis	-0.0475	0.0104	<.001
Depression	0.0073	0.0098	.46
Wald test of independent equations		$\chi^2 = 23,633.31$	<.001

^aAmong 84,244 persons (251,949 person-period observations). Models also include Department of Veterans Affairs (VA) medical center fixed effects.
^bReference 32.5 or fewer days.
^cReference black race/ethnicity.
^dRange, 1-13.

■ **Appendix D. Second-Stage Equation Predicting A1C^a Levels**

Variable	β Level	SE	P
Wait time >32.5 d ^b	0.1386	0.0184	<.001
Distance to VA medical center	0.0009	0.0001	<.001
Distance to VA outpatient clinic	0.0002	0.0004	.56
Outcome period first half 2003	0.0516	0.0086	<.001
Outcome period second half 2003	-0.0767	0.0092	<.001
Age	-0.0300	0.0007	<.001
Male sex	0.1060	0.0452	.02
White race/ethnicity ^c	-0.0962	0.0164	<.001
Hispanic race/ethnicity ^c	0.0120	0.0387	.76
Asian race/ethnicity ^c	0.0613	0.0877	.48
Native American race/ethnicity ^c	-0.3356	0.0842	<.001
Other race/ethnicity ^c	-0.0121	0.0542	.82
Priority status 1-3	-0.0089	0.0120	.46
Diabetes Complications Severity Index	0.1125	0.0045	<.001
Congestive heart failure	0.0380	0.0222	.09
Cardiac arrhythmia	-0.0635	0.0211	.003
Valvular disease	-0.0812	0.0340	.02
Pulmonary circulation disorder	0.1026	0.0874	.24
Peripheral vascular disease	-0.0957	0.0191	<.001
Hypertension	-0.0189	0.0140	.18
Paralysis	-0.5313	0.0566	<.001
Other neurological disorder	-0.3573	0.0374	<.001
Chronic pulmonary disease	-0.0330	0.0161	.04
Hypothyroidism	0.0060	0.0261	.82
Renal failure	-0.4957	0.0280	<.001
Liver disease	-0.2959	0.0507	<.001
Peptic ulcer disease, including bleeding	-0.0108	0.0433	.80
AIDS	-0.6819	0.1229	<.001
Lymphoma	-0.0884	0.0767	.25
Metastatic cancer	-0.1342	0.0907	.14
Solid tumor without metastasis	-0.0196	0.0174	.26
Rheumatoid arthritis or collagen vascular disease	-0.1475	0.0415	<.001
Coagulopathy	-0.0044	0.0468	.93
Obese	0.0370	0.0151	.01
Weight loss	-0.1332	0.0590	.02
Fluid and electrolyte disorders	-0.0002	0.0328	>.99
Blood loss anemia	-0.0719	0.1139	.53
Deficiency anemia	-0.2026	0.0224	<.001
Alcohol abuse	-0.2081	0.0396	<.001
Drug abuse	-0.0314	0.0638	.62
Psychosis	-0.2015	0.0218	<.001
Depression	0.0564	0.0204	.006

^aAmong 84,244 persons (251,949 person-period observations). Models also include Department of Veterans Affairs (VA) medical center fixed effects.

^bReference 32.5 or fewer days.

^cReference black race/ethnicity.

^dRange, 1-13.