

Supplementary Online Content

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This supplementary material has been provided by the authors to give readers additional information about their work.

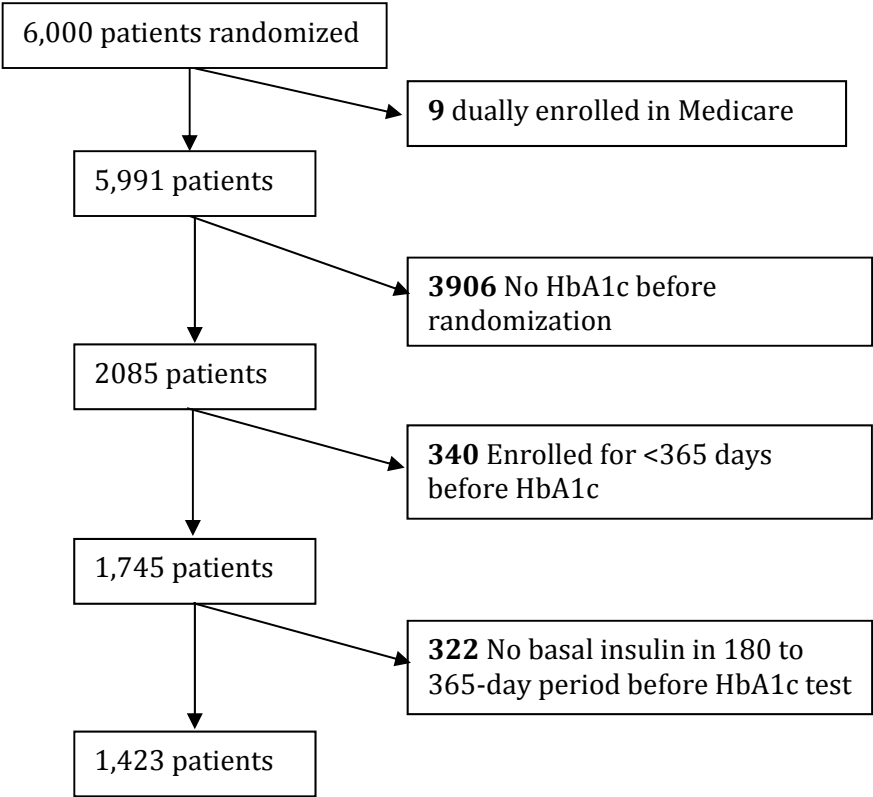
eTable 1. Measurement of factors

Factors	Measurement
Age	Enrollment files
Gender	Enrollment files
COPD/Asthma	ICD-9 codes: 490.xx, 491.xx, 492.xx, 496.xx; 493.xx; ICD-10 codes: J45, J40, J41, J42, J43
CHF	ICD-9 codes: 428.xx, 398.91, 402.01, 402.11, 402.91, 404.01, 404.11, 404.91, 404.03, 404.13, 404.93; ICD-10 codes: I50, I11.0
Depression	ICD-9 codes: 311.xx, 296.2, 296.3, 300.4, 301.12, 309.1; ICD-10: F33, F32
Hypertension	ICD-9 codes: 401.xx-405.xx, 437.2; ICD-10 codes: I10, I11, I12, I13, I15, I16, I674, N262
Hyperlipidemia	ICD-9: 272; ICD-10: E78, E76, E88
Liver disease	ICD-9 codes: 570.xx-573.xx, 456.00–456.21; ICD-10 codes: K76, K70, K71, K72, K73, K74
Osteoporosis	ICD-9: 733; ICD-10: M81
Alzheimer's/Dementia	ICD-9: 290, 294.1, 294.9, 330, 331; ICD-10: E75, F01, F02, F03, F05, G13, G30, G31, G91
Hypoglycemia	ICD-9: 251.2; ICD-10: E16.2, E11.649, E16.1, E16.0
Diabetic ketoacidosis	ICD-9 codes: 250.1x; ICD-10 codes: E10.10
Kidney disease	ICD-9 codes: 582.xx, 583.xx, 585.xx, 586.xx, 587.xx, 250.4, 250.40, 250.41, 250.42, 250.43, 403.xx, 404.xx, 585.6; ICD-10 codes: N18, N19, N17, E09, E10, E1, E13
Macrovascular disease	ICD-9 codes: 410.xx-414.xx, 429.2, V45.81, 433.x1, 434.x1, 435.x, 436, 437.1x, 437.9x, 438.x; ICD-10 codes: I60, I61, I63, I64; E12.5, E13.5, E14.5, I20-I25
Microvascular disease	ICD-9 codes: 362.01-362.07, 583.81, 250.6, 357.2; ICD-10: E10.2, E11.2, E12.2, E13.2, E14.2, E10.3, E11.3, E12.3, E13.3, E14.3, E10.4, E11.4, E12.4, E13.4, E14.4
Use of insulin listed on formulary	Pharmacy claims indicator for the basal insulin
Insulin copayment	Pharmacy claims for first initiated basal insulin in baseline period
Insulin persistence	Pharmacy claims: Gap between insulin fills >60 days
Mail order use	Pharmacy claims indicator
Rapid-acting insulin	Pharmacy claims: fill for insulin lispro, insulin aspart, or insulin glulisine
Oral medications	Counting the number of unique medications in pharmacy claims: sulfonylurea, meglitinide, biguanide, thiazolidinedione, alpha-glucosidase inhibitor, SGLT2 inhibitors, DPP4-inhibitor, or GLP1 agonists
Type of basal insulin	Pharmacy claims for first initiated insulin in baseline period
No. of glucose self-testing supply fills	Pharmacy claims: fills for test strips or lancets
Endocrinologist use	Office visit with an endocrinologist defined by NPI
No. of primary care office visits	No. of outpatient office visits with "family medicine" or "primary care" defined by NPI

Abbreviations: ICD-9, International Classification of Disease 9th edition (before October 1, 2015); ICD-10, International Classification of Disease 10th edition (beginning October 1, 2016); COPD, Chronic obstructive

pulmonary disease; CHF, Congestive Heart Failure; SGLT2, Sodium-glucose co-transporter 2; DPP4, dipeptidyl peptidase 4; GLP1, glucose-dependent insulinotropic peptide; NPI, National Provider Identifier; CPT, Current Procedural Terminology

eFigure. Cohort flow diagram



eTable 2. Pairwise correlation coefficients between regressors (p-values)

	Female	Age	CHF	COPD/Asthma	Depression	Hyperlipidemia	Hypertension	Liver disease	Osteoporosis	Alzheimer's/dementia	Hypoglycemia	Ketoacidosis	Kidney disease	Macrovascular disease	Microvascular disease	Rapid-acting insulin	No. diabetes drugs	Type of basal insulin	Persistence	No. supply fills	Endocrinologist	PCP office visits	Formulary use	Insulin copay	Mail order use
Female	1.00																								
Age	-0.01 (0.66)	1.00																							
CHF	-0.07 (0.01)	0.10 (0.00)	1.00																						
COPD/Asthma	0.07 (0.01)	0.02 (0.36)	0.09 (0.004)	1.00																					
Depression	0.12 (<0.001)	-0.01 (0.68)	0.01 (0.83)	0.05 (0.06)	1.00																				
Hyperlipidemia	-0.08 (0.002)	0.12 (<0.001)	0.07 (0.001)	0.06 (0.03)	0.06 (0.02)	1.00																			
Hypertension	-0.02 (0.35)	-0.02 (0.35)	0.13 (<0.001)	0.10 (<0.001)	0.04 (0.15)	0.32 (<0.001)	1.00																		
Liver disease	0.07 (0.01)	0.07 (0.01)	-0.01 (0.64)	0.03 (0.19)	0.10 (<0.001)	0.07 (0.97)	0.06 (0.02)	1.00																	
Osteoporosis	0.16 (<0.001)	0.16 (<0.001)	0.05 (0.05)	0.08 (0.002)	0.10 (<0.001)	0.07 (0.01)	0.05 (0.05)	0.01 (0.65)	1.00																
Alzheimer's/dementia	0.03 (0.28)	0.03 (0.28)	0.04 (0.17)	0.14 (<0.001)	0.09 (<0.001)	0.05 (0.09)	0.04 (0.15)	0.14 (<0.001)	0.04 (0.18)	1.00															
Hypoglycemia	-0.02 (0.51)	-0.04 (0.11)	0.02 (0.43)	0.05 (0.86)	0.09 (<0.001)	0.05 (0.09)	0.01 (0.68)	0.00 (0.86)	0.04 (0.17)	0.02 (0.52)	1.00														
Diabetic ketoacidosis	0.00 (0.97)	-0.13 (<0.001)	0.03 (0.26)	-0.03 (0.30)	0.08 (0.003)	-0.01 (0.61)	0.01 (0.80)	0.04 (0.13)	0.03 (0.27)	0.03 (0.22)	0.02 (0.36)	1.00													
Kidney disease	-0.02 (0.51)	0.05 (0.05)	0.09 (<0.001)	0.06 (0.02)	0.05 (0.05)	0.13 (<0.001)	0.17 (<0.001)	0.04 (0.13)	0.07 (0.006)	0.03 (0.32)	0.05 (0.07)	0.05 (0.07)	1.00												
Macrovascular disease	-0.10 (<0.001)	0.19 (<0.001)	0.31 (<0.001)	0.13 (<0.001)	0.05 (0.04)	0.18 (<0.001)	0.25 (<0.001)	0.03 (0.22)	0.01 (0.86)	0.12 (<0.001)	0.03 (0.25)	0.02 (0.44)	0.02 (<0.001)	1.00											
Microvascular disease	-0.05 (0.09)	0.12 (<0.001)	0.08 (0.002)	0.06 (0.04)	0.01 (0.61)	0.07 (0.009)	0.13 (<0.001)	0.02 (0.53)	0.08 (0.002)	0.03 (0.25)	0.04 (0.11)	0.02 (0.40)	0.16 (<0.001)	0.13 (<0.001)	1.00										
Rapid-acting insulin use	0.003 (0.90)	-0.11 (<0.001)	0.02 (0.39)	0.06 (0.03)	0.02 (0.45)	-0.01 (0.72)	-0.07 (0.01)	0.00 (0.73)	0.04 (0.10)	0.01 (0.70)	0.08 (0.004)	0.07 (0.01)	0.14 (<0.001)	0.08 (0.001)	0.07 (0.006)	1.00									
No. of diabetes drugs	-0.02 (0.47)	0.12 (<0.001)	-0.07 (0.006)	-0.04 (0.12)	0.01 (0.65)	0.09 (<0.001)	-0.07 (0.01)	0.04 (0.09)	0.04 (0.10)	-0.03 (0.23)	-0.06 (0.02)	-0.03 (0.20)	0.03 (0.27)	-0.03 (0.20)	-0.07 (0.008)	-0.37 (<0.001)	1.00								
Basal insulin																		1.00							
<i>Glargine 100u/ml</i>	-0.01 (0.69)	0.03 (0.20)	-0.01 (0.81)	-0.02 (0.36)	0.03 (0.34)	0.04 (0.17)	0.03 (0.28)	0.01 (0.57)	-0.03 (0.28)	0.02 (0.40)	0.00 (0.89)	-0.05 (0.08)	0.00 (0.86)	0.00 (0.90)	-0.03 (0.34)	-0.13 (<0.001)	0.00 (0.96)	1.00	0.00 (0.98)	0.00 (0.98)	-0.05 (0.13)	-0.08 (0.002)	0.34 (<0.001)	-0.03 (0.25)	0.00 (0.85)
<i>Detemir</i>	0.01 (0.66)	0.02 (0.49)	0.01 (0.84)	0.04 (0.10)	-0.05 (0.09)	0.00 (0.97)	0.01 (0.67)	0.02 (0.44)	-0.01 (0.70)	-0.04 (0.15)	-0.02 (0.46)	0.01 (0.70)	-0.03 (0.22)	-0.02 (0.46)	0.01 (0.72)	-0.01 (0.64)	0.13 (<0.001)	0.00 (0.79)	-0.03 (0.28)	0.00 (0.91)	0.07 (0.01)	0.21 (<0.001)	-0.06 (0.02)	0.00 (0.99)	
<i>NPH</i>	0.03 (0.28)	-0.01 (0.82)	-0.02 (0.39)	-0.03 (0.20)	0.02 (0.49)	-0.03 (0.23)	-0.03 (0.25)	-0.04 (0.10)	0.04 (0.17)	0.04 (0.10)	0.01 (0.65)	0.01 (0.58)	-0.02 (0.50)	0.04 (0.68)	0.04 (0.13)	-0.07 (0.01)	-0.12 (<0.001)	0.02 (0.51)	0.01 (0.82)	-0.03 (0.31)	0.02 (0.40)	-0.22 (<0.001)	0.01 (0.58)	0.02 (0.43)	
<i>Lispro protamine</i>	-0.02 (0.49)	-0.09 (0.00)	0.01 (0.68)	0.01 (0.66)	0.01 (0.84)	-0.04 (0.18)	-0.07 (0.01)	-0.02 (0.37)	0.04 (0.10)	0.00 (0.86)	0.03 (0.29)	0.05 (0.07)	0.05 (0.08)	0.00 (0.91)	-0.03 (0.22)	0.26 (<0.001)	-0.12 (<0.001)	0.00 (0.90)	0.05 (0.09)	0.04 (0.10)	0.03 (0.31)	-0.82 (<0.001)	0.15 (<0.001)	0.00 (0.87)	
<i>Glargine 300u/ml</i>	-0.01 (0.75)	0.03 (0.20)	0.02 (0.44)	-0.03 (0.24)	0.02 (0.38)	-0.02 (0.53)	0.05 (0.05)	0.01 (0.71)	0.00 (0.85)	-0.01 (0.63)	0.01 (0.81)	0.02 (0.42)	0.03 (0.27)	0.03 (0.21)	0.07 (0.008)	0.11 (<0.001)	-0.04 (0.12)	0.00 (0.98)	0.00 (0.85)	0.10 (<0.001)	0.00 (0.77)	-0.01 (0.71)	0.00 (0.85)	-0.05 (0.08)	
Insulin persistence	-0.03 (0.20)	0.03 (0.34)	0.01 (0.89)	-0.01 (0.69)	-0.07 (0.01)	0.02 (0.47)	-0.02 (0.45)	-0.03 (0.23)	0.01 (0.63)	-0.02 (0.52)	-0.03 (0.33)	-0.09 (0.001)	-0.03 (0.29)	0.00 (0.86)	0.07 (0.01)	0.00 (0.96)	-0.02 (0.40)	1.00							
No. testing supply fills	-0.01 (0.76)	0.01 (0.71)	0.01 (0.64)	-0.01 (0.65)	0.02 (0.41)	0.02 (0.46)	0.00 (0.92)	-0.02 (0.54)	0.00 (0.97)	0.01 (0.77)	0.02 (0.48)	0.02 (0.49)	0.09 (0.001)	0.05 (0.07)	0.03 (0.33)	0.16 (<0.001)	-0.08 (0.003)		1.00						

Endocrinologist use	0.01 (0.73)	-0.08 (0.003)	-0.03 (0.19)	0.05 (0.08)	0.09 (<0.001)	0.10 (<0.001)	0.02 (0.37)	0.03 (0.23)	0.04 (0.16)	0.06 (0.03)	0.09 (0.001)	0.05 (0.06)	0.33 (<0.001)	0.06 (0.03)	0.13 (<0.001)	0.25 (<0.001)	0.02 (0.41)		-0.01 (0.70)	0.09 (<0.001)	1.00				
Primary care office visits	0.05 (0.04)	0.10 (<0.001)	0.13 (<0.001)	0.12 (<0.001)	0.10 (<0.001)	0.16 (<0.001)	0.17 (<0.001)	0.10 (<0.001)	0.10 (<0.001)	0.05 (0.08)	0.07 (0.005)	0.07 (0.01)	0.08 (0.003)	0.09 (0.001)	0.06 (0.03)	0.02 (0.50)	0.003 (0.90)		0.02 (0.56)	0.05 (0.05)	-0.10 (<0.001)	1.00			
Insulin listed on formulary	-0.00 (0.88)	0.09 (<0.001)	0.02 (0.55)	0.01 (0.89)	-0.02 (0.43)	0.04 (0.09)	0.08 (0.002)	0.03 (0.26)	-0.06 (0.02)	-0.01 (0.79)	-0.02 (0.56)	-0.06 (0.03)	-0.05 (0.08)	-0.02 (0.46)	0.02 (0.56)	-0.24 (<0.001)	0.13 (<0.001)		-0.01 (0.68)	-0.05 (0.04)	-0.05 (0.07)	-0.05 (0.08)	1.00		
Insulin copayment	-0.01 (0.78)	-0.03 (0.26)	-0.04 (0.17)	-0.01 (0.63)	-0.01 (0.90)	-0.04 (0.17)	-0.05 (0.09)	-0.01 (0.60)	0.01 (0.75)	-0.05 (0.07)	0.00 (0.93)	-0.01 (0.84)	0.00 (0.92)	-0.04 (0.09)	-0.02 (0.48)	0.02 (0.48)	0.01 (0.59)		0.00 (0.92)	-0.11 (<0.001)	0.03 (0.25)	-0.03 (0.20)	-0.14 (<0.001)	1.00	
Use of mail order	-0.07 (0.01)	0.09 (<0.001)	-0.01 (0.58)	-0.01 (0.91)	0.00 (0.96)	-0.04 (0.10)	-0.07 (0.01)	-0.02 (0.45)	0.01 (0.78)	0.07 (0.007)	-0.04 (0.16)	-0.05 (0.08)	-0.01 (0.63)	-0.02 (0.43)	-0.02 (0.53)	0.05 (0.06)	0.00 (0.89)		-0.04 (0.10)	-0.08 (0.005)	-0.01 (0.69)	-0.05 (0.04)	-0.01 (0.63)	0.08 (0.003)	1.00

Abbreviations: CHF, Congestive Heart Failure; COPD, Chronic obstructive pulmonary disease; NPH, insulin isophane; PCP, Primary Care Provider

eTable 3. Association of factors with adequate glycemic control: Reduced model

Characteristic (Ref: No)	Adjusted Relative Risk (95% CI)
Non-modifiable patient factors	
Age*	1.01 (1.00-1.02)
Diabetes care delivery and patient behavior factors	
<i>Drug therapy</i>	
Use of adjunct rapid acting insulin	0.89 (0.73-1.01)
<i>Patient behavior</i>	
Insulin persistence	1.17 (0.96-1.42)
No. glucose self-testing fills*	1.01 (1.00-1.02)
<i>Model of care and insurance structure</i>	
Endocrinologist use	1.35 (1.16-1.58)
Use of mail order	1.25 (1.04-1.49)

*Per 1-unit increase

Abbreviations: Ref, Referent; CI, Confidence Interval

eTable 4. Association of factors with adequate glycemic control by sex subgroup

Factor (Ref: No)	Men Adjusted Relative Risk (95% CI)	Women Adjusted Relative Risk (95% CI)	Age <66 years Adjusted Relative Risk (95% CI)	Age ≥66 years Adjusted Relative Risk (95% CI)
Non-modifiable patient				
<i>Demographic</i>				
Age* (for stratification by sex)	1.01 (1.00-1.03)	1.00 (0.99-1.02)	-	-
Female (for stratification by age)	-	-	0.98 (0.72-1.31)	0.87 (0.71-1.05)
<i>Clinical comorbidities</i>				
Congestive heart failure	0.88 (0.57-1.37)	1.23 (0.62-2.44)	0.54 (0.17-1.75)	1.07 (0.72-1.57)
COPD/Asthma	1.14 (0.85-1.54)	1.03 (0.72-1.48)	1.32 (0.87-2.00)	0.96 (0.73-1.26)
Depression	0.84 (0.54-1.31)	1.09 (0.74-1.61)	0.84 (0.50-1.40)	0.95 (0.67-1.34)
Hyperlipidemia	0.97 (0.76-1.25)	0.99 (0.73-1.32)	1.04 (0.75-1.44)	0.95 (0.75-1.19)
Hypertension	1.15 (0.88-1.51)	0.92 (0.65-1.28)	0.95 (0.69-1.33)	1.13 (0.86-1.50)
Liver disease	1.03 (0.67-1.60)	0.92 (0.58-1.47)	1.00 (0.56-1.81)	0.97 (0.67-1.41)
Osteoporosis	1.13 (0.63-2.03)	1.08 (0.72-1.62)	1.19 (0.54-2.64)	1.09 (0.76-1.58)
Alzheimer's/dementia	1.39 (0.62-3.11)	1.48 (0.57-3.86)	1.82 (0.52-6.36)	1.43 (0.71-2.88)
<i>Disease progression/control</i>				
Hypoglycemia	0.77 (0.44-1.36)	1.29 (0.67-2.49)	0.86 (0.43-1.74)	0.93 (0.54-1.59)
Diabetic ketoacidosis	0.73 (0.32-1.67)	1.32 (0.56-3.08)	0.69 (0.31-1.54)	0.95 (0.39-2.32)
Kidney disease	0.89 (0.71-1.10)	1.10 (0.83-1.46)	1.02 (0.74-1.40)	0.91 (0.74-1.12)
Macrovascular disease	0.90 (0.70-1.16)	0.95 (0.65-1.38)	0.89 (0.56-1.41)	0.94 (0.74-1.18)
Microvascular disease	0.94 (0.76-1.16)	0.94 (0.72-1.24)	1.08 (0.78-1.50)	0.93 (0.77-1.13)
Diabetes care delivery and patient behavior				
<i>Drug therapy</i>				
Adjunct rapid acting insulin	0.96 (0.76-1.16)	0.74 (0.55-0.99)	0.84 (0.60-1.18)	0.87 (0.70-1.08)
No. unique oral diabetes drugs*	0.94 (0.87-1.03)	1.02 (0.91-1.14)	1.00 (0.89-1.28)	0.96 (0.88-1.04)
Insulin type (ref: glargine 100u/mL)				
Detemir	1.14 (0.57-2.26)	1.19 (0.90-1.56)	0.98 (0.71-1.36)	1.06 (0.86-1.30)
NPH	1.12 (0.66-1.88)	0.70 (0.35-1.39)	1.02 (0.48-2.15)	0.89 (0.54-1.46)
Lispro protamine	0.77 (0.39-1.55)	0.56 (0.24-1.30)	0.60 (0.24-1.52)	0.71 (0.38-1.35)
Glargine 300u/mL	1.14 (0.57-2.26)	1.19 (0.90-1.56)	1.25 (0.47-3.32)	1.05 (0.51-2.18)
<i>Patient behavior</i>				
Insulin persistence	1.14 (0.88-1.48)	1.24 (0.90-1.71)	1.02 (0.7-1.46)	1.21 (0.95-1.54)
No. glucose self-testing fills*	1.01 (1.00-1.02)	1.02 (1.00-1.04)	1.02 (1.00-1.04)	1.01 (1.00-1.02)
<i>Model of care and insurance structure:</i>				
Endocrinologist use	1.45 (1.16-1.80)	1.26 (0.96-1.66)	1.42 (1.02-1.96)	1.42 (1.15-1.74)
Primary care office visits*	1.01 (1.00-1.01)	0.99 (0.97-1.01)	1.01 (0.99-1.03)	1.00 (0.99-1.01)
Use of insulin on formulary	0.86 (0.47-1.57)	0.67 (0.35-1.27)	0.56 (0.26-1.24)	0.87 (0.52-1.48)
Insulin copayment*	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (0.99-1.00)	1.00 (0.99-1.00)
Use of mail order	1.15 (0.91-1.45)	1.39 (1.02-1.90)	1.24 (0.87-1.79)	1.20 (0.97-1.50)

*Per 1-unit increase

Abbreviations: Ref, Referent; CI, Confidence Interval; COPD, chronic obstructive pulmonary disease; NPH, insulin isophane