

Diabetes, Gaps in Care Coordination, and Preventable Adverse Events

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Given their high burden of diabetes-related organ damage and chronic comorbid conditions,¹⁻³ patients with diabetes may receive care from health care providers in different specialties.^{1,4,5} Although receiving care from multiple health care providers may be clinically appropriate, patients' health information is not always shared among providers.^{6,7} When providers do not communicate with each other, they may not coordinate evaluations or treatments, which could result in duplicate tests, drug-drug interactions, excess procedures, and avoidable emergency department (ED) visits and hospitalizations.⁸⁻¹¹

Patients are aware of gaps that may occur in their care coordination^{10,12,13} and of adverse health care–related events that they perceive could have been prevented with better care coordination, herein referred to as preventable adverse events.¹⁰ However, little is known about patient-reported gaps in care coordination or preventable adverse events among patients with diabetes. It is unclear whether reported gaps in care coordination are associated with preventable adverse events among patients with diabetes. If patients with diabetes are more likely to report gaps in care coordination and preventable adverse events compared with those without diabetes, this would represent undesirable care processes that are potentially modifiable.

The aim of this study was to determine whether adults with diabetes are more likely to report gaps in care coordination or, separately, preventable adverse events vs those without diabetes. We also determined whether self-reported gaps in care coordination are associated with self-reported preventable adverse events among adults with diabetes. To accomplish these aims, we analyzed data from the REasons for Geographic And Racial Differences in Stroke (REGARDS) study.

METHODS

Study Population

REGARDS is a population-based cohort study that recruited 30,239 Black and White adults 45 years and older from the 48 contiguous US states and the District of Columbia between January 2003 and October 2007. Black adults and adults residing in the Southeastern United States were oversampled by design.¹⁴ Participants completed

ABSTRACT

OBJECTIVES: To compare the frequency of self-reported gaps in care coordination and self-reported preventable adverse events among adults with vs without diabetes.

STUDY DESIGN: Cross-sectional analysis of REasons for Geographic And Racial Differences in Stroke (REGARDS) study participants 65 years and older who completed a survey on health care experiences in 2017-2018 (N = 5634).

METHODS: We analyzed the association of diabetes with self-reported gaps in care coordination and with preventable adverse events. Gaps in care coordination were assessed using 8 validated questions. Four self-reported adverse events were studied (drug-drug interactions, repeat medical tests, emergency department visits, and hospitalizations). Respondents were asked if they thought these events could have been prevented with better communication among providers.

RESULTS: Overall, 1724 (30.6%) participants had diabetes. Among participants with and without diabetes, 39.3% and 40.7%, respectively, reported any gap in care coordination. The adjusted prevalence ratio (aPR) for any gap in care coordination for participants with vs without diabetes was 0.97 (95% CI, 0.89-1.06). Any preventable adverse event was reported by 12.9% and 8.7% of participants with and without diabetes, respectively. The aPR for any preventable adverse event for participants with vs without diabetes was 1.22 (95% CI, 1.00-1.49). Among participants with and without diabetes, the aPRs for any preventable adverse event associated with any gap in care coordination were 1.53 (95% CI, 1.15-2.04) and 1.50 (95% CI, 1.21-1.88), respectively (*P* comparing aPRs = .922).

CONCLUSIONS: Interventions to improve quality of care for patients with diabetes could incorporate patient-reported gaps in care coordination to aid in preventing adverse events.

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a computer-assisted telephone interview (CATI) and an in-home study visit at baseline and during 2013-2016, and they completed follow-up phone interviews every 6 months following baseline to identify potential stroke and myocardial infarction (MI) events that were adjudicated by experts based on medical records. Between August 2017 and November 2018, during one of their follow-up interviews, REGARDS study participants were invited to complete a survey on experiences with health care. The institutional review boards at all participating institutions approved the REGARDS study, and all participants provided written informed consent.

We analyzed data from REGARDS study participants who were active in the cohort at the time the survey on experiences with health care was administered and who agreed to complete the survey (**eAppendix Figure 1** [eAppendix available at ajmc.com]). We restricted the analysis to participants who were 65 years or older at the time of the survey, who reported having 2 or more health care visits with 2 or more health care providers in the 12 months prior to the survey (because those with only 1 visit to 1 provider were not at risk for problems with care coordination), who reported having a regular health care provider, and who reported seeing that provider in the 6 months prior to the survey. We excluded participants who did not complete the second CATI and in-home study visit and who were missing data on self-reported diabetes or self-reported use of glucose-lowering medication. Lastly, among participants who did not meet our definition of diabetes as defined in the next section, we excluded participants who were missing data on blood glucose levels, whose fasting blood glucose was 126 mg/dL or greater, or whose nonfasting blood glucose was 200 mg/dL or greater. These participants were excluded because they could have undiagnosed diabetes and may not have been receiving the same care for the condition as participants whose diabetes was diagnosed. In total, 5634 participants were included in the current analysis.

Diabetes

Diabetes was defined by a self-reported diagnosis of diabetes, self-reported use of glucose-lowering medication, or identification of a glucose-lowering medication on a medication inventory conducted at the second REGARDS in-home study visit. Participants taking metformin without other glucose-lowering medication who did not report a prior diagnosis of diabetes were not considered to have diabetes because these participants could have been taking metformin for prediabetes or weight loss.^{15,16} Participants not meeting this definition were considered to not have diabetes.

Gaps in Care Coordination and Preventable Adverse Events

We analyzed 7 gaps in care coordination (**eAppendix Table 1**) and 4 preventable adverse events (**eAppendix Table 2**) using data

TAKEAWAY POINTS

In the current analysis of 5634 adults 65 years and older who completed a survey on their experiences with health care in 2017-2018:

- ▶ Gaps in care coordination were common among adults with and without diabetes.
- ▶ Participants with diabetes were more likely than those without diabetes to report an adverse event they felt would have been preventable with better care coordination.
- ▶ Reporting a gap in care coordination was associated with a higher likelihood of reporting a preventable adverse event among participants with and without diabetes.
- ▶ Interventions to improve quality of care for diabetes could identify and address patient-reported gaps in care coordination to prevent adverse events.

from the survey on experiences with health care.¹⁰ The 7 gaps in care coordination were defined based on 8 questions. Six of the questions assessed participants' perceptions of the coordination of their care in the past 6 months (eg, "In the last 6 months, when you visited your personal doctor for a scheduled appointment, how often did he or she have your medical records or other information about your care?" [never, sometimes, usually, or always]). Two questions assessed participants' overall perception of communication among their health care providers (eg, "In general, do you think the doctors who you see communicate with each other about your care?" [yes, no, or I don't know]). The 4 preventable adverse events were (1) a medical test that was repeated because the results of the first test, conducted previously, were not available; (2) a drug-drug interaction caused by doctors prescribing medications that "did not go well together"; (3) an ED visit the participant felt would have been preventable with better care coordination; and (4) a hospital admission the participant felt would have been preventable with better care coordination.

Potential Confounders

We analyzed data on potential confounders such as age, annual household income, body mass index (BMI), hypertension, dyslipidemia, chronic kidney disease (CKD), atrial fibrillation, and peripheral artery disease, which were assessed at the second CATI and second in-home study visit. We also analyzed data on sex, race, educational attainment, and region of residence, which were assessed at the REGARDS study baseline. History of MI and stroke were defined using data from the baseline and second CATIs and study visits supplemented by adjudicated outcome events. We analyzed data on the number of ambulatory visits and ambulatory providers that participants reported having in the 12 months prior to completing their survey on experiences with health care. Among participants with diabetes, we also analyzed data on the duration of diabetes and insulin use, utilizing information collected at the second CATI and in-home study visit. Finally, for an explanatory analysis, we analyzed data on the number of prescription medications taken in the 2 weeks prior to each participant's second in-home study visit. **eAppendix Table 3** shows the definitions of these variables. **eAppendix Figure 2** shows a schematic of the study design.

Statistical Analysis

We calculated summary statistics for participant characteristics and the proportion of participants who reported gaps in care coordination and preventable adverse events, overall and separately for those with and without diabetes. Three Poisson regression models with robust variance estimators were used to calculate prevalence ratios (PRs) and 95% CIs for reporting at least 1 gap in care coordination among participants with vs without diabetes. Model 1 was unadjusted. Model 2 included adjustment for age, sex, race, educational attainment, annual household income, and region of residence. Model 3 included adjustment for all variables in model 2 and the following clinical variables: BMI, hypertension, dyslipidemia, CKD, history of MI, history of stroke, atrial fibrillation, and peripheral artery disease. We also calculated the count of gaps in care coordination reported by participants. The distribution of the count of gaps was overdispersed with a large number of zero values, so we used marginalized zero-inflated Poisson regression models with adjustment as described above to calculate the ratio of the mean count among participants with vs without diabetes.¹⁷

We calculated PRs and 95% CIs for reporting at least 1 preventable adverse event associated with diabetes using 3 Poisson regression models with robust variance estimators and adjustment for potential confounders as described above. Adults with diabetes may take more prescription medications than those without diabetes. In an explanatory model, we calculated the PR and 95% CI for reporting at least 1 preventable adverse event associated with diabetes, including adjustment for the potential confounders in model 3 and number of prescription medications being taken. We considered the number of prescription medications to be a potential variable in the causal pathway because one mechanism by which gaps in care coordination may cause harm is through lack of communication about prescribing, which can lead to drug-drug interactions.^{18,19} Few participants had more than 1 preventable adverse event, so we did not compare the count of adverse events among those with vs without diabetes.

Among participants with and without diabetes, we calculated the PR and 95% CI for reporting at least 1 preventable adverse event associated with reporting at least 1 vs 0 gaps in care coordination. The models included adjustment for covariates as described above, a main effect for diabetes, and an interaction term between diabetes and gaps in care coordination, which was used to assess effect modification by diabetes status. In exploratory analyses, we compared the report of gaps in care coordination and preventable adverse events, and the association between gaps in care coordination and preventable adverse events among participants with diabetes using vs not using insulin.

RESULTS

Participant Characteristics

The proportions of participants who were Black, who had an annual household income less than \$25,000, and who had comorbid conditions were higher in those with vs without diabetes, whereas the

proportion who were college graduates was lower in participants with diabetes (**Table 1**). Compared with participants without diabetes, those with diabetes were taking more prescription medications. Participants with diabetes reported a higher number of health care providers and health care visits in the 12 months preceding the survey on experiences with health care compared with their counterparts without diabetes. Among participants with diabetes, the median duration of diabetes was 11 years and 28% were using insulin.

Gaps in Care Coordination

eAppendix Table 4 shows the frequency of each of the 7 gaps in care coordination, overall and in those with and without diabetes, separately. Among participants with diabetes, 39.3% reported at least 1 gap in care coordination compared with 40.7% in those without diabetes (**Table 2**). In the fully adjusted model, diabetes was not associated with reporting at least 1 gap in care coordination (adjusted PR [aPR], 0.97; 95% CI, 0.89-1.06). Diabetes was also not associated with the number of gaps in care coordination (ratio, 0.93; 95% CI, 0.84-1.03) (**eAppendix Table 5**).

Preventable Adverse Events

Participants with diabetes were more likely to report a drug-drug interaction, any ED visit, and any hospitalization vs those without diabetes (**eAppendix Table 6**). The proportion of participants who reported at least 1 preventable adverse event was 12.9% among those with diabetes and 8.7% in those without diabetes (**Table 3**). After multivariable adjustment for all potential confounders (model 3), the prevalence of reporting at least 1 preventable adverse event was higher for participants with vs without diabetes (aPR, 1.22; 95% CI, 1.00-1.49). After further adjustment for number of prescription medications (explanatory model), the aPR for reporting at least 1 preventable adverse event in adults with vs without diabetes was 1.10 (95% CI, 0.89-1.35).

Gaps in Care Coordination and Preventable Adverse Events

Among participants with diabetes, the proportion who reported at least 1 preventable adverse event was higher among those with at least 1 vs 0 gaps in care coordination (**Table 4**). The proportion of participants without diabetes reporting at least 1 preventable adverse event was also higher among those reporting at least 1 vs 0 gaps in care coordination. After multivariable adjustment, the aPRs for reporting at least 1 preventable adverse event associated with reporting at least 1 gap in care coordination were 1.53 (95% CI, 1.15-2.04) among participants with diabetes and 1.50 (95% CI, 1.21-1.88) among those without diabetes (*P* comparing PRs = .922).

Insulin, Gaps in Care Coordination, and Preventable Adverse Events

Among participants with diabetes, there was no association between insulin use and reporting a gap in care coordination (aPR, 0.88; 95% CI, 0.73-1.05) (**eAppendix Table 7**) or reporting a preventable adverse

TABLE 1. Characteristics of Participants Included in the Current Study, Overall and Among Those With and Without Diabetes, Separately

Characteristic	Overall N = 5634	Without diabetes n = 3910	With diabetes n = 1724	P (without vs with)
Age in years, mean (SD)	73.0 (6.6)	73.2 (6.7)	72.6 (6.3)	.002
Women, n (%)	3109 (55.2)	2166 (55.4)	943 (54.7)	.642
Black, n (%)	1919 (34.1)	1085 (27.8)	834 (48.4)	<.001
Annual income <\$25,000, n (%)	1076 (20.3)	652 (17.7)	424 (26.4)	<.001
Educational attainment, n (%)				
Less than high school	321 (5.7)	183 (4.7)	138 (8.0)	<.001
High school	1214 (21.6)	773 (19.8)	441 (25.6)	
Some college	1446 (25.7)	954 (24.4)	492 (28.5)	
College graduate or above	2653 (47.1)	2000 (51.2)	653 (37.9)	
Region of residence, n (%)				
Stroke Buckle ^a	1251 (22.2)	843 (21.6)	408 (23.7)	.010
Stroke Belt ^b	1827 (32.4)	1241 (31.7)	586 (34.0)	
Other US region	2556 (45.4)	1826 (46.7)	730 (42.3)	
Body mass index, n (%)				
< 25 kg/m ²	1324 (23.6)	1122 (28.7)	202 (11.8)	<.001
25 kg/m ² to <30 kg/m ²	2090 (37.2)	1510 (38.7)	580 (33.8)	
≥30 kg/m ²	2206 (39.3)	1273 (32.6)	933 (54.4)	
Hypertension, n (%)	3855 (68.4)	2441 (62.5)	1414 (82.0)	<.001
Dyslipidemia, n (%)	3470 (62.7)	2231 (57.7)	1239 (74.3)	<.001
Chronic kidney disease, n (%)	2148 (39.9)	1379 (36.5)	769 (48.1)	<.001
Myocardial infarction, n (%)	831 (15.2)	493 (13.0)	338 (20.5)	<.001
Stroke, n (%)	333 (5.9)	187 (4.8)	146 (8.5)	<.001
Atrial fibrillation, n (%)	609 (11.3)	413 (10.9)	196 (12.0)	.241
Peripheral artery disease, n (%)	196 (3.5)	122 (3.1)	74 (4.3)	.033
Number of ambulatory providers, ^c n (%)				
2 providers	1790 (31.8)	1313 (33.6)	477 (27.7)	<.001
3 providers	1730 (30.7)	1236 (31.6)	494 (28.6)	
4 providers	1042 (18.5)	690 (17.6)	352 (20.4)	
≥5 providers	1072 (19.0)	671 (17.2)	401 (23.3)	
Number of ambulatory visits, ^c median [25th-75th percentiles]	5 [3-8]	5 [3-8]	6 [4-9]	<.001
Duration of diabetes in years, median [25th-75th percentiles]	—	—	11 [6-20]	—
Insulin use, n (%)	—	—	353 (28.0)	—
Number of prescription medications, median [25th-75th percentiles]	5 [3-8]	4 [2-6]	7 [5-10]	<.001

^aThe stroke buckle includes the coastal plains region of North Carolina, South Carolina, and Georgia.

^bThe stroke belt includes the remaining parts of North Carolina, South Carolina, and Georgia, and Alabama, Mississippi, Tennessee, Arkansas, and Louisiana.

^cIn the 12 months preceding the survey on experiences with health care.

event (aPR, 1.03; 95% CI, 0.72-1.46) (eAppendix Table 8). In fully adjusted models, the aPRs for reporting at least 1 preventable adverse event associated with at least 1 vs 0 gaps in care coordination were 2.65 (95% CI, 1.45-4.83) in participants using insulin and 1.41 (95% CI, 1.02-1.96) in those with diabetes not using insulin (*P* comparing PRs = .069) (eAppendix Table 9).

DISCUSSION

In the current national study of Black and White adults 65 years and older who received care from multiple health care providers,

there was no difference in self-reported gaps in care coordination by diabetes status. However, compared with those without diabetes, participants with diabetes were more likely to report an adverse event that they perceived could have been prevented with better care coordination. This difference appears to be explained, at least in part, by participants with diabetes taking more prescription medications, a risk factor for drug-drug interactions, vs those without diabetes. Participants with diabetes who reported any vs no gap in care coordination were more likely to report any preventable adverse event. The association between reporting any gap in care coordination and reporting any preventable adverse event

TABLE 2. Prevalence Ratios for at Least 1 Self-reported Gap in Care Coordination Associated With Diabetes Status

	Without diabetes n = 3910	With diabetes n = 1724
Participants with ≥ 1 gap in care coordination, n (%)	1590 (40.7)	677 (39.3)
Prevalence ratio (95% CI)		
Model 1 ^a	1 (ref)	0.97 (0.90-1.04)
Model 2 ^b	1 (ref)	0.94 (0.87-1.01)
Model 3 ^c	1 (ref)	0.97 (0.89-1.06)

Ref, reference.

^aModel 1 is unadjusted.

^bModel 2 includes adjustment for age, sex, race, educational attainment, annual household income, and region of residence.

^cModel 3 includes adjustment for variables in model 2 and for body mass index, hypertension, dyslipidemia, chronic kidney disease, history of myocardial infarction, history of stroke, atrial fibrillation, and peripheral artery disease.

appeared to be stronger among participants with diabetes using vs not using insulin.

In the current study, 39% of patients with diabetes reported a gap in care coordination. This proportion is quite high considering that most of the questions used to assess gaps in care coordination were restricted to the past 6 months. Improving diabetes quality of care has been a major goal in health care for decades, but quality improvement efforts have largely focused on increasing patient engagement in recommended screening tests and controlling intermediate clinical outcomes such as blood glucose levels.^{20,21} Patients' experiences of care coordination are not often considered in quality measures for diabetes.²² The high proportion of patients with diabetes who report problems with care coordination suggests a need for quality improvement efforts in this area of care.

The current study adds to the existing literature by showing that patients with diabetes are aware of experiencing adverse events and that they attribute many of those events to poor care coordination. The current study also suggests that participants with diabetes may be more likely to report a preventable adverse event compared with their counterparts without diabetes despite not experiencing more gaps in care coordination. Previous studies have shown that patients with diabetes take more medications²³ and have higher risk for any hospitalization vs those without diabetes.²⁴ Therefore, experiencing gaps in care coordination may be particularly hazardous to patients with diabetes. Consistently, the association of diabetes with higher report of preventable adverse events in the current analysis was attenuated and no longer statistically significant after adjustment for number of prescription medications being taken. This finding supports the inference that patients with diabetes taking multiple medications need particular monitoring for gaps in communication among prescribers.

TABLE 3. Prevalence Ratios for at Least 1 Self-reported Preventable Adverse Event Associated With Diabetes Status

	Without diabetes n = 3910	With diabetes n = 1724
Participants with ≥ 1 preventable adverse event, n (%)	339 (8.7)	223 (12.9)
Prevalence ratio (95% CI)		
Model 1 ^a	1 (ref)	1.49 (1.27-1.75)
Model 2 ^b	1 (ref)	1.32 (1.11-1.57)
Model 3 ^c	1 (ref)	1.22 (1.00-1.49)
Explanatory model ^d	1 (ref)	1.10 (0.89-1.35)

Ref, reference.

^aModel 1 is unadjusted.

^bModel 2 includes adjustment for age, sex, race, educational attainment, annual household income, and region of residence.

^cModel 3 includes adjustment for variables in model 2 and for body mass index, hypertension, dyslipidemia, chronic kidney disease, history of myocardial infarction, history of stroke, atrial fibrillation, and peripheral artery disease.

^dThe explanatory model includes adjustment for potential confounders in model 3 and accounts for the number of prescription medications taken in the 2 weeks prior to each participant's second in-home study visit.

Using data from the REGARDS study, Kern et al previously showed that adults who report a gap in care coordination are more likely to report preventable adverse events.¹⁰ The current study expands prior knowledge by showing that this association is present among adults with diabetes. The current study also suggests that the association between gaps in care coordination and preventable adverse events may be stronger among adults with diabetes taking vs not taking insulin. Patients using insulin have more diabetes-related complications than those with diabetes not using this medication.²⁵ Experiencing gaps in care coordination may have a more deleterious effect on the occurrence of preventable adverse events in adults with diabetes using vs not using insulin, a hypothesis that needs to be confirmed in future studies.

Previous quality improvement efforts for adults with diabetes have typically selected patients based on their hemoglobin A_{1c} level or a recent hospitalization, which is appropriate, but this strategy may miss some opportunities for improvement.²⁶⁻²⁸ A future intervention to improve care coordination for patients with diabetes might start with identifying those who perceive that their care is not well coordinated. Patient safety experts have shown that patients' perceptions of their care often have merit.²⁹ Therefore, addressing patients' concerns may help prevent future adverse events.

Strengths and Limitations

The current study has several strengths. The analysis included a large, national sample of patients with and without diabetes. Gaps in care coordination were assessed using previously validated questions. The current study also has several limitations. Diabetes was defined, in part, by self-report, which may have resulted in some misclassification. Gaps in care coordination and preventable adverse events were both defined using self-report of events occurring over long periods (ie, 6 and 12 months). Thus, there is the potential for

TABLE 4. Prevalence Ratios for at Least 1 Preventable Adverse Event Associated With Reporting at Least 1 vs 0 Gaps in Care Coordination Among Participants With and Without Diabetes, Separately

	Without diabetes		With diabetes		P ^a
	0 gaps in care coordination	≥ 1 gap in care coordination	0 gaps in care coordination	≥ 1 gap in care coordination	
N	2320	1590	1047	677	
Participants with ≥ 1 preventable adverse event, n (%)	168 (7.2)	171 (10.8)	109 (10.4)	114 (16.8)	
Prevalence ratio (95% CI)					
Model 1 ^b	1 (Ref)	1.49 (1.21-1.82)	1 (Ref)	1.62 (1.27-2.06)	0.598
Model 2 ^c	1 (Ref)	1.49 (1.21-1.84)	1 (Ref)	1.48 (1.15-1.92)	0.976
Model 3 ^d	1 (Ref)	1.50 (1.21-1.88)	1 (Ref)	1.53 (1.15-2.04)	0.922

Ref, reference.

^aP value comparing prevalence ratios by diabetes status.

^bModel 1 is unadjusted.

^cModel 2 includes adjustment for age, sex, race, educational attainment, annual household income, and region of residence.

^dModel 3 includes adjustment for variables in model 2 and for body mass index, hypertension, dyslipidemia, chronic kidney disease, history of myocardial infarction, history of stroke, atrial fibrillation, and peripheral artery disease.

inaccurate recall. Additionally, some of the questions about gaps in care coordination referred to events occurring over the 6 months preceding the survey on experiences with health care, whereas questions about preventable adverse events included events occurring over the 12 preceding months. It is possible that preventable adverse events may have preceded the gaps in care coordination in some participants. Lastly, the outcomes in the current study were subjective. Participants may have understood the question about drug-drug interactions (ie, medications not going well together) differently from one another. In addition, whether participants' ED visits and hospitalizations could have been prevented with better-coordinated care cannot be known for certain.

CONCLUSIONS

A high proportion of older adults with and without diabetes receiving care from multiple health care providers reported a problem with the coordination of their care. Adults with diabetes were more likely to report an adverse event that they attributed to poor care coordination compared with their counterparts without diabetes. The frequency of these problems remains quite high despite decades of work to improve the quality of care for patients with diabetes. Whereas previous interventions to improve diabetes care have typically identified patients for inclusion based on severity of illness or transitions in care, this work suggests that new interventions are needed, which would identify patients based on their experiences of care. Identifying and addressing patient-reported gaps in care coordination would be a novel strategy that may increase quality of care, increase patient satisfaction, and improve patient safety. ■

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eAppendix Table 1. Questions used to define gaps in care coordination from the survey module on experiences with healthcare.

Questions	Definition of gaps in care coordination
In the last 6 months, when you visited your personal doctor for a scheduled appointment, how often did he or she have your medical records or other information about your care?	A gap in care coordination was defined by a response of “sometimes” or “never.”
In the last 6 months, how often did you and your personal doctor talk about all the prescription medicines you were taking?	A gap in care coordination was defined by a response of “sometimes” or “never.”
In the last 6 months, how often did your personal doctor seem informed and up-to-date about the care you got from specialists?	A gap in care coordination was defined by a response of “sometimes” or “never.”
In the last 6 months, did you get the help you needed from your personal doctor’s office to manage your care among these different providers and services?	A gap in care coordination was defined by a response of “somewhat.”
<p>^aIn the last 6 months, when your personal doctor ordered a blood test, x-ray, or other test for you, how often did someone from your personal doctor’s office follow up to give you those results?</p> <p>*In the last 6 months, when your personal doctor ordered a blood test, x-ray, or other test for you, how often did you get those results as soon as you needed them?</p>	A gap in care coordination was defined by a response of “sometimes” or “never” to either of these two questions.
In general, do you think the doctors that you see communicate with each other about your care?	A gap in care coordination was defined by a response of “no.”
In general, how would you describe the coordination among all of the different health professionals that you see?	A gap in care coordination was defined by a response of “fair” or “poor.”

^aThese questions were combined as per the Consumer Assessment of Healthcare Providers and Systems scoring rule.¹

eAppendix Table 2. Questions used to define preventable adverse events from the survey module on experiences with healthcare.

Questions	Definitions preventable adverse events
In the past 12 months, have you been told to repeat a blood test, x-ray, or other test that you had had in the past two weeks, because your doctor did not have the results of the first test?	Participants who responded “yes” were considered to have had a preventable adverse event.
In the past 12 months, have you had a problem with your medication because different doctors prescribed medication that did not go well together?	Participants who responded “yes” were considered to have had a preventable adverse event.
<ol style="list-style-type: none"> 1. In the past 12 months, have you had one or more emergency department visits? 2. Do you think one or more of your emergency department visits could have been prevented? 3. Do you think one or more of your emergency department visits could have been prevented by better communication across your different doctors and other healthcare providers? 	Participants who responded “yes” to the third question were considered to have had a preventable adverse event.
<ol style="list-style-type: none"> 1. In the past 12 months, have you been admitted to the hospital at least once? 2. Do you think one or more of your hospitalizations could have been prevented? 3. Do you think one or more of your hospitalizations could have been prevented by better communication across your different doctors and other healthcare providers? 	Participants who responded “yes” to the third question were considered to have had a preventable adverse event.

eAppendix Table 3. Definitions of participant characteristics analyzed in the current study.

Characteristics	Definitions
Age	Age at the second REGARDS in-home study visit was calculated by subtracting participants' date of birth from their second in-home study visit date.
Gender	Self-reported as Male or Female at the REGARDS study baseline.
Race	Self-reported as Black or White at the REGARDS study baseline. Race was considered a social construct.
Annual household income	Self-reported annual household income from any source at the second REGARDS CATI. We categorized the variable as <\$25,000 and ≥\$25,000.
Educational attainment	Self-reported highest level of education completed at the REGARDS study baseline. We categorized the variable as less than high school, high school, some college, and college graduate.
Region of residence	Defined using data collected at the REGARDS study baseline and categorized as stroke buckle, stroke belt, and other US regions. The stroke buckle includes the coastal plain of North Carolina, South Carolina and Georgia. The stroke belt includes the remaining parts of North Carolina, South Carolina and Georgia, and Tennessee, Mississippi, Alabama, Louisiana and Arkansas. Other US regions include the remaining 40 contiguous US states and the District of Columbia.
Body mass index	Calculated as weight (kg)/height (m ²) using data collected at the second REGARDS in-home study visit. We categorized the variable as <25 kg/m ² , 25 to <30 kg/m ² , and ≥30 kg/m ² .
Hypertension	Defined as a systolic blood pressure ≥140 mm Hg or a diastolic blood pressure ≥90 mm Hg or self-reported current use of antihypertensive medication using data collected at the second REGARDS CATI and in-home study visit.
Dyslipidemia	Defined as a total cholesterol ≥240 mg/dL or a low-density lipoprotein cholesterol ≥160 mg/dL, or a high-density lipoprotein cholesterol ≤ 40 mg/dL, or self-reported use of lipid-lowering medication using data collected at the second REGARDS CATI and in-home study visit.
Chronic kidney disease	Defined as an estimated glomerular filtration rate < 60 ml/min per 1.73 m ² or a urinary albumin to creatinine ratio ≥ 30 mg/g. The estimated glomerular filtration rate was calculated based on serum creatinine measured at the second REGARDS in-home study visit and the chronic

	kidney disease Epidemiology Collaboration (CKD-EPI) equation. Albumin-to-creatinine ratio was calculated based on creatinine and albumin measured using urine samples collected at the second REGARDS in-home study visit.
History of myocardial infarction	Defined as evidence of a myocardial infarction on an electrocardiogram conducted at the second REGARDS in-home study visit or a self-reported history of myocardial infarction at the second CATI, or an adjudicated myocardial infarction event between baseline and the second REGARDS in-home study visit.
History of stroke	Defined as a self-reported history of stroke at the REGARDS study baseline or an adjudicated stroke event between baseline and the second REGARDS in-home study visit.
Atrial fibrillation	Defined as evidence of atrial fibrillation on a study electrocardiogram or self-reported history of atrial fibrillation at the second REGARDS CATI/in-home study visit.
Peripheral artery disease	Defined as self-reporting ever having had a procedure to fix the arteries in one's legs at the second REGARDS CATI.
Number of ambulatory visits in the prior 12 months	Self-reported during the survey module on experiences with healthcare.
Number of ambulatory providers in the prior 12 months	Self-reported during the survey module on experiences with healthcare.
Duration of diabetes	Duration of diabetes at the second REGARDS study in-home study visit was calculated by subtracting participants' self-reported age at diabetes diagnosis from their age at the second REGARDS in-home study visit.
Insulin use	Obtained from the medication inventory conducted at the second REGARDS in-home study visit.
Number of prescription medications	Obtained from the medication inventory conducted at the second REGARDS in-home study visit.

CATI: Computer-assisted telephone interview; REGARDS: REasons for Geographic and Racial Differences in Stroke.

eAppendix Table 4. Frequency of self-reported gaps in care coordination overall and among participants with and without diabetes, separately.

Gaps in care coordination	Overall N = 5,634	Without diabetes N = 3,910	With diabetes N = 1,724	P-value
In the past 6 months, the personal doctor only sometimes or never had medical records or other information about the respondent's care when he or she had a scheduled appointment.	175 (3.1)	113 (2.9)	62 (3.6)	0.158
In the past 6 months, the personal doctor only sometimes or never talked about all of the prescription medicines the respondent was taking.	942 (16.7)	664 (17.0)	278 (16.1)	0.439
In the past 6 months, the personal doctor seemed informed and up-to-date about care the respondent received from specialists sometimes or never.	475 (8.4)	320 (8.2)	155 (9.0)	0.323
In the past 6 months, the respondent only somewhat received or did not receive the help he or she needed from the personal doctor's office to manage his or her care among different providers and services.	698 (12.4)	476 (12.2)	222 (12.9)	0.456
In the past 6 months, the respondent's personal doctor's office followed up only sometimes or never to provide the results of a blood test, x-ray, or other test that the personal doctor had ordered.	633 (11.2)	434 (11.1)	199 (11.5)	0.647
In the past 6 months, the respondent only sometimes or never received the results of a blood test, x-ray, or other test ordered by their personal doctor as soon as they needed them?	476 (8.5)	338 (8.6)	138 (8.0)	0.436
The respondent thinks that, in general, the doctors he or she sees do not communicate with each other about his or her care.	588 (10.4)	451 (11.5)	137 (8.0)	<0.001
The respondent rates the coordination of care among all of the health professionals that he or she sees, in general, as fair or poor.	430 (7.6)	318 (8.1)	112 (6.5)	0.034
Any gap in care coordination	2,267 (40.2)	1,590 (40.7)	677 (39.3)	0.331

eAppendix Table 5. Diabetes status and number of gaps in care coordination.

	Without diabetes N = 3,910	With diabetes N = 1,724
Gaps in care coordination, n (%)		
0	2,320 (59.3)	1,047 (60.7)
1	775 (19.8)	349 (20.2)
2	422 (10.8)	161 (9.3)
3	212 (5.4)	84 (4.9)
4	92 (2.4)	52 (3.0)
≥5	89 (2.3)	31 (1.8)
Mean ± SD	0.80 ± 1.3	0.76 ± 1.2
Ratio of mean numbers of questions reporting gaps in care coordination (95% confidence intervals) ^a		
Model 1	1 (Ref)	0.95 (0.87 - 1.03)
Model 2	1 (Ref)	0.91 (0.83 - 0.99)
Model 3	1 (Ref)	0.93 (0.84 - 1.03)

Model 1 is unadjusted.

Model 2 includes adjustment for age, gender, race, educational attainment, annual household income, and region of residence.

Model 3 includes adjustment for variables in Model 2 and body mass index, hypertension, dyslipidemia, chronic kidney disease, history of myocardial infarction, history of stroke, atrial fibrillation, and peripheral artery disease.

^a Ratios were calculated using marginalized zero-inflated Poisson regression models.

eAppendix Table 6. Frequency of self-reported preventable adverse events among participants with and without diabetes, separately.

Type of outcome experiences by the Respondent over the previous 12 months	Overall number who responded Yes (Numerator) / Denominator* (%)	Number without diabetes (Numerator) / Denominator* (%)	Number with diabetes (Numerator) / Denominator* (%)	P-value
Repeat test				
Repeated a blood test, x-ray, or other test that the participant had had in the past 2 weeks because his or her doctor did not have the results of the first test (Outcome 1).	179/5,634 (3.2)	118/3,910 (3.0)	61/1,724 (3.5)	0.323
Drug-drug interaction				
Had a problem with his or her medications, because different doctors prescribed medications that did not go well together (Outcome 2).	343/5,634 (6.1)	200/3,910 (5.1)	143/1,724 (8.3)	<0.001
Emergency department visit				
Has had ≥ 1 emergency department (ED) visit.	1,383/5,634 (24.6)	893/3,910 (22.8)	490/1,724 (28.4)	<0.001
Believes ED visit could have been prevented.	385/1,383 (27.8)	246/893 (27.5)	139/490 (28.4)	0.754
Believes ED visit could have been prevented by better communication across his or her doctors and other healthcare professionals (Outcome 3).	83/385 (21.6)	55/246 (22.4)	28/139 (20.1)	0.699
Hospital admission				
Has had ≥ 1 hospital admission.	1,124/5,634 (20.0)	708 /3,910(18.1)	416/1,724 (24.1)	<0.001
Believes hospital admission could have been prevented.	181/1,124 (16.1)	100/708 (14.1)	81/416 (19.5)	0.023
Believes hospital admission could have been prevented by better communication across his or her doctors and other healthcare professionals (outcome 4).	46/181 (25.4)	20/100 (20.0)	26/81 (32.1)	0.086
Any of the 4 adverse preventable outcomes.	562/5,634 (10.0)	339/3,910 (8.7)	223/1,724 (12.9)	<0.001

eAppendix Table 7. Prevalence ratios for ≥ 1 self-reported gap in care coordination associated with insulin use.^a

	Not using insulin N = 1,371	Using insulin N = 353
Participants with ≥ 1 gap in care coordination, N (%)	550 (40.1)	127 (36.0)
Prevalence ratio (95% CI)		
Model 1	1 (Ref)	0.90 (0.77-1.05)
Model 2	1 (Ref)	0.87 (0.74-1.02)
Model 3	1 (Ref)	0.88 (0.73-1.05)

^a Analysis restricted to participants with diabetes.

Model 1 is unadjusted.

Model 2 includes adjustment for age, gender, race, educational attainment, annual household income, and region of residence.

Model 3 includes adjustment for variables in Model 2 and body mass index, hypertension, dyslipidemia, chronic kidney disease, history of myocardial infarction, history of stroke, atrial fibrillation, and peripheral artery disease.

eAppendix Table 8. Prevalence ratios ≥ 1 self-reported preventable adverse event associated with insulin use.^a

	Not using insulin N = 1,371	Using insulin N = 353
Participants with ≥ 1 preventable adverse event, N (%)	175 (12.8)	48 (13.6)
Prevalence ratio (95% CI)		
Model 1	1 (Ref)	1.07 (0.79-1.43)
Model 2	1 (Ref)	1.08 (0.79-1.46)
Model 3	1 (Ref)	1.03 (0.72-1.46)

^a Analysis restricted to participants with diabetes.

Model 1 is unadjusted.

Model 2 includes adjustment for age, gender, race, educational attainment, annual household income, and region of residence.

Model 3 includes adjustment for variables in Model 2 and body mass index, hypertension, dyslipidemia, chronic kidney disease, history of myocardial infarction, history of stroke, atrial fibrillation, and peripheral artery disease.

eAppendix Table 9. Prevalence ratios for ≥ 1 self-reported preventable adverse event associated with ≥ 1 self-reported gap in care coordination among participants with diabetes, stratified by insulin use.

	Not using insulin		Using insulin		p-value*
	0 gaps in care coordination	≥ 1 gap in care coordination	0 gaps in care coordination	≥ 1 gap in care coordination	
N	821	550	226	127	
Participants with ≥ 1 preventable adverse event, N (%)	88 (10.7)	87 (15.8)	21 (9.3)	27 (21.3)	
Prevalence ratio (95% CI)					
Model 1	1 (Ref)	1.48 (1.12-1.94)	1 (Ref)	2.29 (1.35-3.88)	0.149
Model 2	1 (Ref)	1.40 (1.04-1.88)	1 (Ref)	2.29 (1.35-3.90)	0.111
Model 3	1 (Ref)	1.41 (1.02-1.96)	1 (Ref)	2.65 (1.45-4.83)	0.069

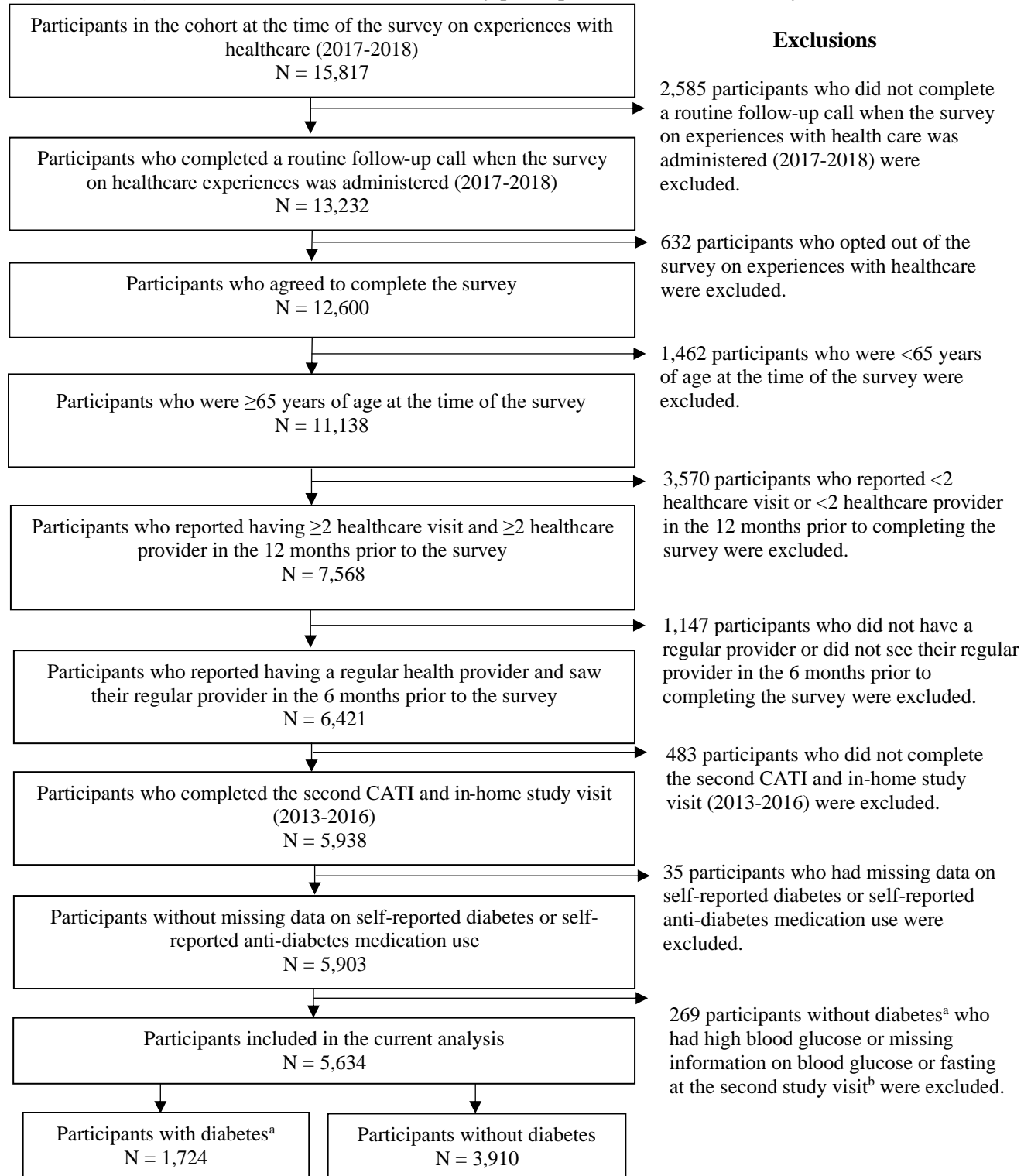
Model 1 is unadjusted.

Model 2 includes adjustment for age, gender, race, educational attainment, annual household income, and region of residence.

Model 3 includes adjustment for variables in Model 2 and body mass index, hypertension, dyslipidemia, chronic kidney disease, history of myocardial infarction, history of stroke, atrial fibrillation, and peripheral artery disease.

^aP-value comparing prevalence ratios.

eAppendix Figure 1. Flowchart of REGARDS study participants included in the analysis.

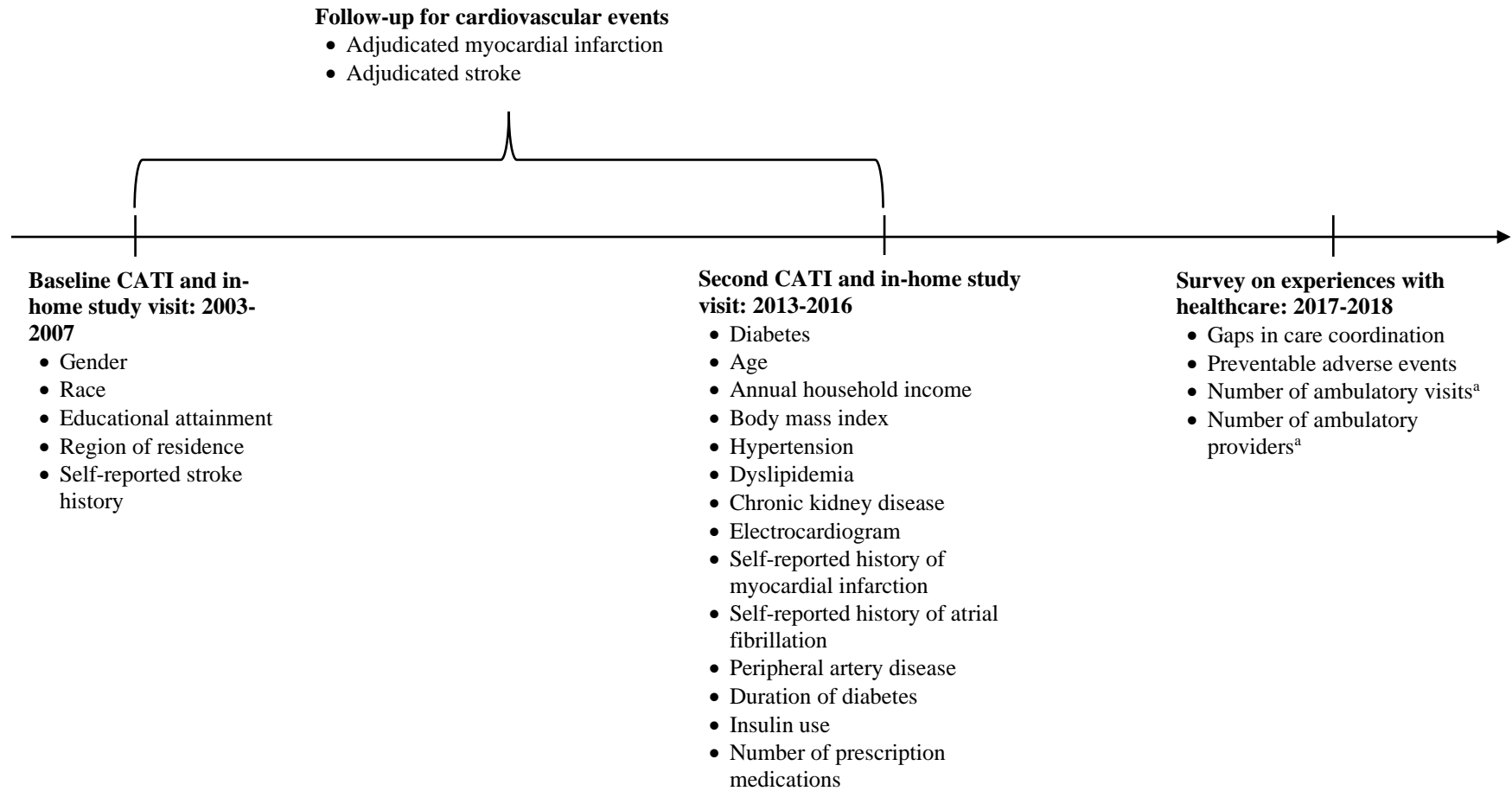


CATI: Computer-assisted telephone interview; REGARDS: REasons for Geographic and Racial Differences in Stroke Study.

^a Diabetes was defined by self-reported diagnosis or use of glucose-lowering medication other than metformin alone.

^b This includes 73 participants who self-reported no prior diagnosis of diabetes but had high blood glucose at the second in-home study visit and 196 participants who self-reported no prior diagnosis of diabetes but had missing data on blood glucose or fasting status at the second in-home study visit.

eAppendix Figure 2. Timing of data collection for variables used in this analysis.



CATI: Computer-assisted telephone interview; REGARDS: REasons for Geographic and Racial Differences in Stroke Study.

^a In the 12 months preceding the survey on experiences with healthcare.

eAppendix References

1. Hays RD, Martino S, Brown JA, et al. Evaluation of a Care Coordination Measure for the Consumer Assessment of Healthcare Providers and Systems (CAHPS) Medicare survey. *Med Care Res Rev.* Apr 2014;71(2):192-202. doi:10.1177/1077558713508205