Cost-Related Medication Nonadherence in Adults With Diabetes in the United States: The National Health Interview Survey 2013–2018

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Diabetes Care 2022;45:594–603 | https://doi.org/10.2337/dc21-1757

OBJECTIVE

Health-related expenditures resulting from diabetes are rising in the U.S. Medication nonadherence is associated with worse health outcomes among adults with diabetes. We sought to examine the extent of reported cost-related medication nonadherence (CRN) in individuals with diabetes in the U.S.

RESEARCH DESIGN AND METHODS

We studied adults age ≥18 years with self-reported diabetes from the National Health Interview Survey (NHIS) (2013–2018), a U.S. nationally representative survey. Adults reporting skipping doses, taking less medication, or delaying filling a prescription to save money in the past year were considered to have experienced CRN. The weighted prevalence of CRN was estimated overall and by age subgroups (<65 and ≥65 years). Logistic regression was used to identify sociodemographic characteristics independently associated with CRN.

RESULTS

Of the 20,326 NHIS participants with diabetes, 17.6% (weighted 2.3 million) of those age <65 years reported CRN, compared with 6.9% (weighted 0.7 million) among those age ≥65 years. Financial hardship from medical bills, lack of insurance, low income, high comorbidity burden, and female sex were independently associated with CRN across age groups. Lack of insurance, duration of diabetes, current smoking, hypertension, and hypercholesterolemia were associated with higher odds of reporting CRN among the nonelderly but not among the elderly. Among the elderly, insulin use significantly increased the odds of reporting CRN (odds ratio 1.51; 95% CI 1.18, 1.92).

CONCLUSIONS

In the U.S., one in six nonelderly and one in 14 elderly adults with diabetes reported CRN. Removing financial barriers to accessing medications may improve medication adherence among these patients, with the potential to improve their outcomes.

In 2018, ∼13% of U.S. adults had diabetes, representing 34 million people (1). The burden of diabetes has increased in recent years in the country, with a

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Received 20 August 2021 and accepted 9 December 2021

This article contains supplementary material online at https://doi.org/10.2337/figshare.17157959.

This article is featured in a podcast available at diabetesjournals.org/journals/pages/diabetes-core-update-podcasts.

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reported 2.5% increase in absolute age-adjusted prevalence over a 10-year period (2008–2018), corresponding to an increase from 26 million to 34 million in the same time period (1,2). In the U.S., diabetes disproportionately affects certain racial/ethnic groups, including non-Hispanic Blacks, Native Americans, South Asians, and Hispanics (especially Mexicans) (1).

As one of the leading causes of morbidity and mortality in the U.S. (3), diabetes imposes a significant financial burden on the health care system and individuals alike (4). The estimated cost of diagnosed diabetes in 2017 was $237 billion in direct medical costs and $90 billion in reduced productivity, a 26% increase from 2012 to 2017. The average annual cost for an individual with diabetes is $16,750, two-thirds of which is attributed directly to diabetes, with insulin alone accounting for one-third of total cost. The overall per capita health care–related expenditure of individuals with diabetes has been reported to be 2.3 times higher when compared with that of those without diabetes (4).

Oral and injectable medications are cornerstones of diabetes management, and medication adherence is essential for adequate glycemic control and prevention of microvascular and macrovascular complications (5). Among U.S. adults with diabetes in 2016, 67% were prescribed at least one antihyperglycemic medication, 11% were prescribed three or more antihyperglycemic medications, and 60% were prescribed statin (6,7). With rising medication costs and the resulting financial hardship exacerbated by the introduction of novel, more expensive medical therapies for diabetes and other comorbid conditions, the issue of affordability will likely worsen in coming years. In the event of financial limitations, patients with diabetes may forgo prescribed medications, leading to unfavorable health outcomes (8,9).

Cost-related nonadherence (CRN) is complex and multifactorial and represents a major issue in caring for patients with diabetes. Studies have shown that CRN is common among individuals with diabetes, particularly in relation to social determinants of health, including perceived financial stress, financial insecurity with health care, food insecurity (10), and adverse socioeconomic and health factors (11). Although informative, these studies have not investigated the variation of CRN across different age groups or the effect of highly prevalent diabetes comorbid conditions on CRN. The current determinants of CRN among individuals with diabetes in the U.S. remain unclear as well.

In this study, we aimed to examine the extent of reported CRN in individuals with diabetes in the U.S. using updated, nationally representative data and determine the relative contribution of various potential upstream factors. We were particularly interested in understanding patterns of CRN in adults with diabetes age <65 years, who do not have universal insurance protections despite long-term health care needs for diabetes, compared with those age ≥ 65 years, who have access to Medicare.

RESEARCH DESIGN AND METHODS

Setting and Study Design

We used 2013–2018 data from the National Health Interview Survey (NHIS) for our analyses. The NHIS, a U.S. nationally representative survey administered by the National Center for Health Statistics/Centers for Disease Control and Prevention, is administered on a yearly basis and uses complex, multistage sampling to provide estimates of prevalence data on the noninstitutionalized U.S. population (12). The NHIS questionnaire is divided into four core components, and questionnaires for each component are administered: Households Composition, Family Core, Sample Child Core, and Sample Adult Core (13). The Household Composition questionnaire collects basic information and relationship information about all individuals in a household. The Family Core questionnaire collects information about sociodemographic characteristics, basic indicators of health status, activity limitations, injuries, health insurance coverage, and access to and use of health care services. From each family, one sample child and one sample adult are randomly selected in order to gather more in-depth information. This study was based on the Sample Adult Core files (with relevant variables added from the Family Core files), which are supplemented with demographic and socioeconomic characteristics, health status, health care services, and health-related behaviors of the U.S. adult population (13). Because NHIS data are publicly available, deidentified data, this study was exempt from the purview of the Houston Methodist Hospital Institutional Review Board Committee (14).

Study Population

We used self-reported data to ascertain diabetes status. Specifically, individuals were considered to have diabetes and therefore were included in the analysis if they answered positively to the following question: "Have you ever been told by a doctor or health professional that you have diabetes or sugar diabetes?" We carried all analyses on two distinct adult age groups separately (nonelderly age 18–64 years; elderly age ≥ 65 years) to capture the nuances of those with and without universal financial protections from public insurance.

Study Outcomes

CRN, our main study outcome, was considered present in individuals who reported doing/having done any of the following to save money in the previous 12 months: skipping medication doses, taking less medicine, or delaying filling a prescription. As secondary outcomes, we also analyzed the following additional self-reported cost-reducing behaviors (to save money): asked doctor for lower-cost medication, bought prescription drugs from another country, and used alternative therapies. Both our main and secondary outcomes have been used as standards in prior literature (10,15–18).

Candidate Factors Associated With CRN

Candidate factors associated with CRN were identified based on prior work in this space (19–21). Covariates in this study were self-reported and included sex, race/ethnicity, education, insurance status, family income, financial hardship from medical bills, U.S. region, years since diabetes diagnosis, insulin use, cardiovascular risk factors, atherosclerotic cardiovascular disease (ASCVD), and number of chronic comorbidities. Categorical variables were classified as follows: two categories for sex, four categories for race/ethnicity (non-Hispanic White, non-Hispanic Black, non-Hispanic Asian, or Hispanic), two categories for education (some college or higher or

high school or lower), three categories for insurance type (public, private, or uninsured), two categories for family income (based on percentage of family income to the federal poverty limit from the Census Bureau) (middle/high income [≥200%] or low income [<200%]), and four categories for geographic region (Northeast, Midwest, South, or West).

The following questions were used in the NHIS to assess financial hardship from medical bills: "In the past 12 months did you/anyone in your family have problems paying or were unable to pay any medical bills? Include bills for doctors, dentists, hospitals, therapists, medication, equipment, nursing home or home care." "Do you/anyone in your family currently have any medical bills that are being paid off over time? This could include medical bills being paid off with a credit card, through personal loans, or bill paying arrangements with hospitals or other providers. The bills can be from earlier years as well as this year."

The cardiovascular risk factors assessed were self-reported and included diagnosis of hypertension, high cholesterol, obesity (calculated as BMI ≥30 kg/m^2), current smoker, or insufficient physical activity (defined as not participating in ≥150 min per week of moderate-intensity aerobic physical activity, ≥75 min per week of vigorous-intensity aerobic physical activity, or a total combination of ≥150 min per week of moderate/vigorous-intensity aerobic physical activity).

Years since diabetes diagnosis was ascertained via self-report and categorized as <10 years or ≥10 years. ASCVD was defined as having coronary artery disease (yes to any of the following three questions: "Have you ever been told by a doctor or other health professional that you had coronary heart disease?", "…angina, also called angina pectoris?", or "…a heart attack [also called myocardial infarction]?") and/or stroke disease (yes to the following question: "Have you ever been told by a doctor or other health professional that you had a stroke?"). Self-reported chronic comorbidities, including emphysema, chronic obstructive pulmonary disease, asthma, gastrointestinal ulcer, cancer (any), arthritis (including arthritis, gout, fibromyalgia, rheumatoid arthritis, and systemic lupus erythematosus), any kind of liver condition, and weak/failing kidneys, were aggregated for this analysis, and participants were categorized as having zero, one, or two or more.

Statistical Analyses

All analyses were carried out using Stata version 16 (StataCorp, LP, College Station, TX). All covariates in the study are displayed for individuals with diabetes, with or without CRN, and stratified by age group. Categorical variables are presented as a number of observations and weighted proportions, and the Rao-Scott χ^2 test was used to test for differences. In addition, the weighted prevalence of CRN was plotted for certain sociodemographic and disease-specific subgroups at higher risk for CRN to see where CRN had the highest impact within each age group (elderly and nonelderly).

Because CRN was a combination of different individual variables, we presented the weighted prevalence of each individual CRN component (including the final composite for CRN) within sociodemographic and clinical factors by age group.

Univariable and multivariable logistic regression models were used to study the association between CRN and the candidate explanatory variables. The explanatory variables were informed by previous literature, and we used the Hosmer-Lemeshow test for the goodness of fit of our multivariable model. The variable for income included 10% missing values, for which we used the multiple imputation files provided by the NHIS. Results from all regression analyses include imputed values for missing income. Excluding income, <5% of NHIS participants from years 2013 to 2018 had missing responses in any of the relevant questions used for this analysis. Those participants were excluded from the present analysis to ensure that the same study population was included in the descriptive analyses and in the regression analyses, which used a complete case approach.

Variance estimation for the entire pooled cohort was obtained from the Integrated Public Use Microdata Series (https://www.ipums.org) (22). For all statistical analyses, $P < 0.05$ was considered statistically significant. All analyses incorporated the survey weights and strata to account for the NHIS complex survey design and reliably produce nationally representative estimates.

RESULTS

Study Population

From 2013 to 2018, 20,326 participants with self-reported diabetes were surveyed in the NHIS (weighted prevalence 9.7%, representing 23.1 million people). Of them, 10,368 (weighted 13.3 million) were nonelderly and 9,958 (weighted 9.79 million) were elderly.

Prevalence of CRN and Its Components

Among nonelderly participants, 1,898 (weighted prevalence 17.6%, representing 2.3 million) reported CRN, whereas among elderly participants, 715 (weighted prevalence 6.9%, representing 0.7 million) reported CRN. Among nonelderly individuals who reported CRN, there were more women (57%) than men (43%), and more than half came from low-income households (55%) (Table 1). Although a majority of nonelderly adults had insurance, 21% did not. Most reported a high burden of comorbidities and cardiovascular risk factors. The frequency of female sex, non-Hispanic White race/ethnicity, low income, lack of insurance, and burden of cardiovascular risk factors and comorbidities was significantly higher in these individuals than in those without CRN (all $P < 0.05$). With regard to diabetes, nonelderly individuals who reported CRN had on average a longer duration of diabetes and were using insulin more frequently than their non-CRN counterparts (35% vs. 30%) ($P < 0.05$).

A higher proportion of women and a higher burden of cardiovascular risk factors and comorbidities were also observed among elderly participants with CRN compared with those without. The prevalence of ASCVD was markedly higher in elderly participants with CRN (41%) than in younger participants with CRN (24%) ($P < 0.05$). With regard to diabetes, there were no statistically significant differences in diabetes duration between elderly individuals with and without CRN ($P = 0.18$), whereas those with CRN were using insulin more frequently (39% vs. 28%) ($P < 0.05$).

Table 1—General characteristics among adults with diabetes, with or without CRN, from the NHIS, 2013–2018

	Adults with diabetes					
	Nonelderly (age 18–64 years)			Elderly (age ≥65 years)		
	No CRN	CRN	*P*	No CRN	CRN	*P*
Sample, *n*	8,470	1,898		9,243	715	
Weighted sample (weighted %)	10,950,851 (82.4)	2,338,902 (17.6)		9,122,442 (93.1)	673,568 (6.9)	
Sex			<0.001			<0.001
Male	52.3 (50.9, 53.8)	43.0 (40.1, 46.0)		51.2 (49.8, 52.5)	40.8 (35.8, 45.7)	
Female	47.7 (46.2, 49.1)	57.0 (54.0, 59.9)		48.8 (47.5, 50.2)	59.2 (54.3, 64.2)	
Race/ethnicity			<0.001			0.010
Non-Hispanic White	57.6 (55.9, 59.2)	59.6 (56.6, 62.7)		69.1 (67.6, 70.6)	63.8 (58.9, 68.7)	
Non-Hispanic Black	17.0 (15.8, 18.2)	19.6 (17.3, 21.9)		13.1 (12.2, 14.1)	18.4 (14.7, 22.2)	
Non-Hispanic Asian	5.9 (5.1, 6.6)	2.1 (1.2, 3.0)		5.0 (4.2, 5.7)	3.7 (2.0, 5.4)*	
Hispanic	19.6 (18.1, 21.1)	18.7 (16.2, 21.2)		12.8 (11.6, 14.0)	14.1 (10.4, 17.8)	
Education			0.02			0.40
Some college or higher	53.7 (52.2, 55.2)	49.9 (46.8, 52.9)		47.2 (45.8, 48.6)	49.3 (44.6, 53.9)	
HS/GED or less than HS	46.3 (44.8, 47.8)	50.1 (47.1, 53.2)		52.8 (51.4, 54.2)	50.7 (46.1, 55.4)	
Insurance status			<0.001			<0.001
Private	54.6 (53.0, 56.1)	40.7 (37.7, 43.6)		2.7 (2.2, 3.1)	2.0 (0.7, 3.2)*	
Public	36.1 (34.7, 37.5)	38.6 (35.8, 41.5)		96.9 (96.4, 97.4)	95.6 (93.7, 97.6)	
Uninsured	9.3 (8.4, 10.2)	20.7 (18.3, 23.1)		0.4 (0.3, 0.6)*	2.4 (0.8, 4.0)*	
Family income			<0.001			<0.001
Middle/high	62.0 (60.4, 63.6)	44.9 (41.9, 47.8)		64.1 (62.6, 65.6)	44.9 (39.9, 49.8)	
Low	38.0 (36.4, 39.6)	55.1 (52.2, 58.1)		35.9 (34.4, 37.4)	55.1 (50.2, 60.1)	
Financial hardship from medical bills, *n* (weighted %)			<0.001			<0.001
No	65.6 (64.2, 67.1)	26.1 (23.5, 28.7)		81.1 (80.0, 82.2)	41.9 (37.5, 46.4)	
Yes	34.4 (32.9, 35.8)	73.9 (71.3, 76.5)		18.9 (17.8, 20.0)	58.1 (53.6, 62.5)	
Region			<0.001			0.38
Northeast	16.2 (15.0, 17.5)	12.2 (10.2, 14.2)		18.1 (16.9, 19.4)	15.7 (12.2, 19.2)	
Midwest	22.2 (20.8, 23.5)	25.9 (23.5, 28.4)		22.4 (21.1, 23.7)	24.1 (19.6, 28.7)	
South	39.8 (38.0, 41.5)	44.9 (41.9, 47.9)		38.9 (37.2, 40.6)	41.7 (36.6, 46.8)	
West	21.8 (20.3, 23.4)	17.0 (14.6, 19.4)		20.6 (19.1, 22.0)	18.5 (14.5, 22.5)	
Years since diabetes diagnosis			<0.001			0.18
<10	56.2 (54.8, 57.6)	50.4 (47.6, 53.3)		31.8 (30.6, 33.0)	35.2 (30.3, 40.2)	
≥10	43.8 (42.4, 45.2)	49.6 (46.7, 52.4)		68.2 (67.0, 69.4)	64.8 (59.8, 69.7)	
Now taking insulin			0.003			<0.001
No	69.6 (68.4, 70.9)	65.0 (62.2, 67.8)		71.8 (70.6, 73.0)	61.4 (56.8, 66.1)	
Yes	30.4 (29.1, 31.6)	35.0 (32.2, 37.8)		28.2 (27.0, 29.4)	38.6 (33.9, 43.2)	
Comorbidities, *n*			<0.001			<0.001
0	44.4 (43.0, 45.8)	26.9 (24.3, 29.4)		24.0 (22.9, 25.1)	12.9 (9.9, 15.9)	
1	32.5 (31.2, 33.7)	33.0 (30.1, 35.8)		37.4 (36.2, 38.7)	34.5 (29.9, 39.0)	
≥2	23.1 (22.0, 24.3)	40.2 (37.3, 43.0)		38.6 (37.3, 39.9)	52.6 (47.8, 57.5)	
ASCVD status			<0.001			0.01
No	83.1 (82.1, 84.1)	76.0 (73.5, 78.5)		64.6 (63.4, 65.9)	58.6 (53.9, 63.3)	
Yes	16.9 (15.9, 17.9)	24.0 (21.5, 26.5)		35.4 (34.1, 36.6)	41.4 (36.7, 46.1)	
Smoking status			<0.001			0.006
Never	57.4 (55.9, 58.8)	46.6 (43.6, 49.6)		50.2 (48.9, 51.5)	46.4 (41.7, 51.2)	
Former	24.1 (22.9, 25.3)	25.9 (23.2, 28.6)		42.3 (41.0, 43.6)	41.6 (36.9, 46.3)	
Current	18.5 (17.4, 19.6)	27.5 (24.7, 30.2)		7.5 (6.8, 8.2)	12.0 (8.7, 15.2)	
Obesity			0.002			<0.001
No	39.0 (37.7, 40.4)	33.8 (31.0, 36.6)		53.8 (52.5, 55.1)	41.3 (36.8, 45.9)	
Yes	61.0 (59.6, 62.3)	66.2 (63.4, 69.0)		46.2 (44.9, 47.5)	58.7 (54.1, 63.2)	
Physical activity			0.007			0.17
Sufficiently active	37.2 (35.8, 38.7)	32.7 (29.8, 35.6)		28.3 (27.1, 29.5)	25.0 (20.8, 29.3)	
Insufficiently active	62.8 (61.3, 64.2)	67.3 (64.4, 70.2)		71.7 (70.5, 72.9)	75.0 (70.7, 79.2)	

Continued on p. 598

Table 1—Continued

	Adults with diabetes					
	Nonelderly (age 18–64 years)			Elderly (age ≥65 years)		
	No CRN	CRN	*P*	No CRN	CRN	*P*
Hypertension			<0.001			0.03
No	36.1 (34.7, 37.4)	29.2 (26.4, 32.0)		20.1 (19.1, 21.2)	15.9 (12.5, 19.3)	
Yes	63.9 (62.6, 65.3)	70.8 (68.0, 73.6)		79.9 (78.8, 80.9)	84.1 (80.7, 87.5)	
High cholesterol			<0.001			0.002
No	42.5 (41.1, 43.9)	33.0 (30.2, 35.7)		32.4 (31.1, 33.7)	25.3 (21.3, 29.2)	
Yes	57.5 (56.1, 58.9)	67.0 (64.3, 69.8)		67.6 (66.3, 68.9)	74.7 (70.8, 78.7)	

Data given as weighted % (95% CI) unless otherwise indicated. HS, high school; GED, General Equivalency Diploma. *These observations are included for descriptive purposes but are insufficient to contribute to national estimates.

Among Medicare beneficiaries, 8.4% of those with supplemental coverage (Part D and/or private) reported CRN compared with 6.2% of individuals without such supplemental coverage (Part A or B only). However, these differences were not statistically significant ($P = 0.08$). (Supplementary Fig. 1).

The prevalence of each component of CRN is presented in Fig. 1. In the nonelderly population, 13.5% reported skipping doses, 13.9% took less medicine, and 16.4% delayed filling a prescription (all to save money). In the elderly population, these prevalences were lower (4.2%, 4.7%, and 5.8%, respectively).

Factors Associated With CRN

The prevalence of CRN was higher within certain subgroups. In unadjusted analyses, nonelderly individuals with ASCVD, hypertension, high cholesterol, diabetes, or obesity; those currently using insulin; those from low-income households; and those with financial hardship from medical bills reported a higher prevalence of CRN. The same unadjusted trends were seen in the elderly population, although at lower magnitudes. Figure 2 shows prevalence ratios of CRN in nonelderly compared with elderly adults with diabetes. The weighted prevalence of each individual component of CRN, by sociodemographic and clinical characteristics, is presented in Supplementary Table 1 (nonelderly) and Supplementary Table 2 (elderly).

The results of univariable and multivariable logistic regression analyses evaluating independent factors associated with CRN are presented in Table 2. Within the nonelderly population, the factors most strongly associated with reporting CRN included financial hardship from medical bills (odds ratio [OR] 4.49; 95% CI 3.82, 5.29), lack of insurance (OR 2.11; 95% CI 1.66, 2.68), higher comorbidity count (one comorbidity: OR 1.60; 95% CI 1.32, 1.93; two or more comorbidities: OR 2.33; 95% CI 1.90, 2.86), low income (OR 1.53; 95% CI 1.29, 1.82), female sex (OR 1.32; 95% CI 1.12, 1.55), and ≥10 years since diabetes diagnosis (OR 1.25; 95% CI 1.06, 1.48). Several cardiovascular risk factors were also associated with higher odds of reporting CRN, including presence of high cholesterol (OR 1.45; 95% CI 1.23, 1.73) and hypertension (OR 1.24; 95% CI 1.03, 1.48) and being a current smoker (OR 1.38; 95% CI 1.15, 1.67). Compared with the other racial/ethnic groups, non-Hispanic Asians had statistically significantly lower odds of reporting CRN in multivariable analyses (OR compared with non-Hispanic Whites 0.58; 95% CI 0.35, 0.95).

Within the elderly population, female sex, low income, financial hardship, and burden of comorbidities remained strongly associated with CRN. In contrast, years since diabetes diagnosis, current smoking, hypertension, and hypercholesterolemia were not statistically associated with CRN in the elderly. On the other hand, current use of insulin had a strong association

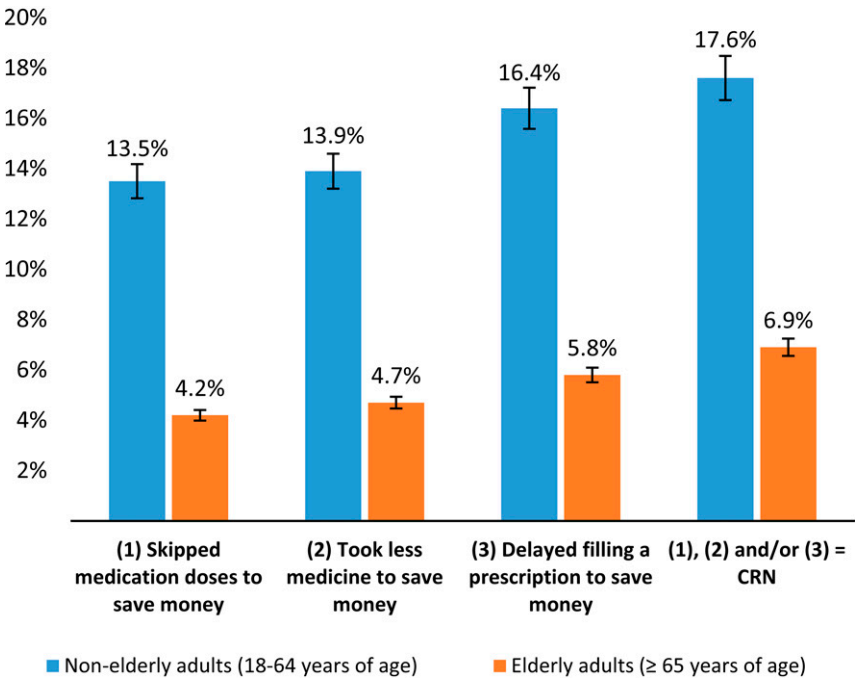

Figure 1—Prevalence of individual components for CRN by age subgroup among adults with diabetes from the NHIS, 2013–2018.

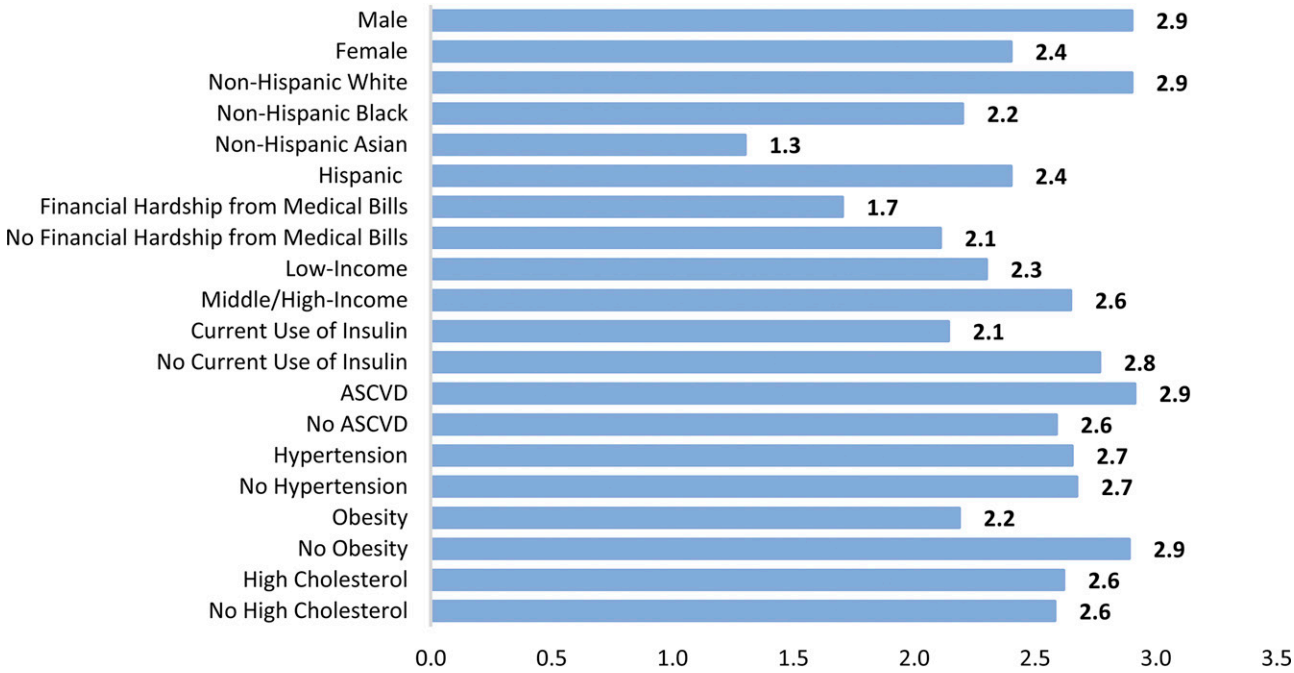

Figure 2—Prevalence ratios of CRN in nonelderly compared with elderly adults with diabetes by high-risk subgroup from the NHIS, 2013–2018.

with CRN in this group (OR 1.51; 95% CI 1.18, 1.92).

Other Cost-Reducing Behaviors

Individuals with CRN engaged much more frequently in cost-reducing behaviors aimed at saving money compared with those without CRN. In nonelderly adults with CRN, 71.4% reported asking their health care provider for a lower-cost medication (vs. 19.7% of those without CRN), 4.3% reported buying prescription medications from another country (vs. 1.5% of those without CRN), and 16.6% reported using alternative therapies (vs. 2.7% of those without CRN). In elderly adults with CRN, the prevalence of cost-reducing behaviors was similar to that in nonelderly adults (Table 3) ($P <$ 0.05 for all comparisons).

CONCLUSIONS

In a U.S. nationally representative study using the most updated data (2013–2018) from the NHIS, we found that one in six nonelderly and one in 14 elderly adults with diabetes reported nonadherence to medications because of costs. Financial hardship from medical bills, low household income, female sex, and greater comorbidity burden were strongly associated with CRN across age groups. The most notable differences in the odds of reporting CRN between nonelderly and elderly adults were lack of insurance and cardiovascular risk factors among nonelderly adults (age $<$65 years) vs. insulin use among elderly adults (age $\geq$65 years). Furthermore, individuals who reported CRN engaged much more frequently in cost-reducing behaviors aimed at saving money compared with those without CRN, such as asking for a lower-cost medication, buying prescription medications from another country, and using alternative therapies.

Our findings build on the prior published literature in this space. A previous NHIS analysis from 2013 estimated the overall prevalence of CRN among adults with diabetes in the U.S. to be 14% (10). Our analysis, using more updated NHIS data and generating age-stratified estimates, revealed a big gap in the prevalence of CRN between nonelderly (17.6%) and elderly (6.9%) individuals with diabetes. This suggests that lack of health insurance, which was remarkably higher among nonelderly than among elderly participants, may be strongly associated with poor medication adherence in patients with diabetes (11,23). Specifically, as opposed to elderly adults, nearly all of whom have Medicare coverage, nonelderly adults had twofold increased odds of reporting CRN when uninsured. For Medicare beneficiaries, elderly individuals with or without supplemental insurance (Part D or private) had similar rates of CRN. This raises the possibility of underinsurance in the elderly population. To further support this, a study by Yala et al. (24) showed that patients with diabetes receiving a low-income subsidy for Medicare Part D were found to have lower out-of-pocket (OOP) costs and better medication adherence, and those with private insurance with a deductible in the nonelderly population with diabetes are more likely to report forgoing needed medical services (25).

In this study, financial hardship from medical bills was the strongest variable associated with CRN, regardless of family income or insurance status. It was reported in 74% and 58% of nonelderly and elderly adults describing CRN, respectively. Furthermore, individuals with CRN engaged much more frequently in cost-reducing behaviors aimed at saving money compared with those without CRN, such as asking their health care provider for a lower-cost medication, buying prescription medications from another country, and using alternative therapies. Our findings suggest that CRN is the natural consequence of financial hardship from medical bills and also suggest that financial hardship from medical bills, CRN, and cost-reducing behaviors cluster in the same individuals, consistent with

Table 2—Factors associated with CRN among adults with diabetes from the NHIS, 2013–2018

	Adults with diabetes			
	Age 18–64 years		Age ≥65 years	
	Model 1*	Model 2†	Model 1*	Model 2†
Sex				
Male	Reference	Reference	Reference	Reference
Female	1.45 (1.27, 1.67)	1.32 (1.12, 1.55)	1.52 (1.23, 1.88)	1.41 (1.09, 1.81)
Race/ethnicity				
Non-Hispanic White	Reference	Reference	Reference	Reference
Non-Hispanic Black	1.11 (0.94, 1.31)	1.02 (0.83, 1.25)	1.52 (1.18, 1.96)	1.05 (0.78, 1.42)
Non-Hispanic Asian	0.35 (0.22, 0.54)	0.58 (0.35, 0.95)	0.81 (0.49, 1.33)	0.90 (0.46, 1.74)
Hispanic	0.92 (0.77, 1.10)	0.97 (0.78, 1.20)	1.19 (0.87, 1.63)	0.88 (0.60, 1.28)
Education				
Some college or higher	Reference	Reference	Reference	Reference
HS/GED or less than HS	1.17 (1.02, 1.33)	0.90 (0.77, 1.05)	0.92 (0.76, 1.12)	0.83 (0.65, 1.05)
Insurance status				
Private	Reference	Reference	—	—
Public	1.44 (1.24, 1.66)	0.91 (0.75, 1.11)	—	—
Uninsured	2.98 (2.48, 3.59)	2.11 (1.66, 2.68)	—	—
Family income				
Middle/high	Reference	Reference	Reference	Reference
Low	2.01 (1.76, 2.29)	1.53 (1.29, 1.82)	2.20 (1.78, 2.71)	1.91 (1.51, 2.42)
Financial hardship from medical bills				
No	Reference	Reference	Reference	Reference
Yes	5.41 (4.64, 6.29)	4.49 (3.82, 5.29)	5.94 (4.88, 7.23)	4.45 (3.55, 5.57)
Region				
Northeast	Reference	Reference	Reference	Reference
Midwest	1.56 (1.24, 1.96)	1.18 (0.91, 1.52)	1.25 (0.89, 1.74)	0.96 (0.66, 1.42)
South	1.50 (1.21, 1.87)	1.08 (0.85, 1.37)	1.24 (0.93, 1.65)	0.92 (0.66, 1.27)
West	1.03 (0.81, 1.33)	1.09 (0.83, 1.44)	1.04 (0.73, 1.47)	1.02 (0.69, 1.52)
Years since diabetes diagnosis				
<10	Reference	Reference	Reference	Reference
≥10	1.26 (1.11, 1.44)	1.25 (1.06, 1.48)	0.86 (0.68, 1.08)	0.81 (0.63, 1.04)
Now taking insulin				
No	Reference	Reference	Reference	Reference
Yes	1.23 (1.07, 1.41)	1.09 (0.92, 1.29)	1.60 (1.30, 1.96)	1.51 (1.18, 1.92)
Comorbidities, *n*				
0	Reference	Reference	Reference	Reference
1	1.68 (1.43, 1.97)	1.60 (1.32, 1.93)	1.71 (1.27, 2.31)	1.58 (1.11, 2.27)
≥2	2.87 (2.45, 3.36)	2.33 (1.90, 2.86)	2.54 (1.90, 3.38)	2.04 (1.43, 2.91)
ASCVD status				
No	Reference	Reference	Reference	Reference
Yes	1.55 (1.34, 1.81)	1.18 (0.98, 1.41)	1.29 (1.06, 1.58)	1.15 (0.91, 1.46)
Smoking status				
Never	Reference	Reference	Reference	Reference
Former	1.32 (1.12, 1.56)	1.17 (0.96, 1.42)	1.06 (0.86, 1.32)	1.10 (0.86, 1.42)
Current	1.83 (1.56, 2.14)	1.38 (1.15, 1.67)	1.72 (1.22, 2.43)	1.23 (0.84, 1.79)
Obesity				
No	Reference	Reference	Reference	Reference
Yes	1.26 (1.09, 1.44)	0.98 (0.83, 1.16)	1.65 (1.36, 2.01)	1.20 (0.95, 1.53)
Physical activity				
Sufficiently active	Reference	Reference	Reference	Reference
Insufficiently active	1.22 (1.06, 1.41)	1.00 (0.83, 1.19)	1.18 (0.93, 1.49)	0.99 (0.74, 1.32)
Hypertension				
No	Reference	Reference	Reference	Reference
Yes	1.37 (1.18, 1.58)	1.24 (1.03, 1.48)	1.34 (1.03, 1.74)	0.98 (0.72, 1.34)

Continued on p. 601

Table 2—Continued

	Adults with diabetes			
	Age 18–64 years		Age ≥65 years	
	Model 1*	Model 2†	Model 1*	Model 2†
High cholesterol				
No	Reference	Reference	Reference	Reference
Yes	1.50 (1.31, 1.73)	1.45 (1.23, 1.72)	1.42 (1.14, 1.76)	1.18 (0.91, 1.54)

Data given as OR (95% CI). HS, high school; GED, General Equivalency Diploma. *Model 1: unadjusted. †Model 2: adjusted for all variables in table (with exception of insurance in elderly group, given that most are insured and observations for uninsured were too small for nationally representative estimates).

previous studies (26). Future public health interventions addressing cost-related barriers are needed to improve medication adherence.

Insulin use has been linked to an increased risk of nonadherence to medical therapy resulting from costs (4,27,28). Our results indicate that insulin is independently associated with CRN in the elderly population. Participants in the standard Part D plan have OOP insulin costs surpassing $1,000. Despite closing the coverage gap and the expected reduction in OOP costs, insulin prices increased by 55% from 2014 to 2019 (29,30). Another important trend affecting overall costs for insulin is the shift in insulin use from the less expensive human insulins to more expensive human insulin analogs (31). Furthermore, newer and more expensive noninsulin diabetic treatment options, including sodium-glucose cotransporter 2 (SGLT2) inhibitors and glucagon-like peptide 1 (GLP-1) receptor agonists, with their favorable cardiovascular and diabetic kidney disease outcomes (32–34), are being used more frequently (35). However, these more novel drugs usually come at higher costs to patients and could have also contributed to higher reported CRN among adults with diabetes between 2005–2007 and 2015–2017, with greater impact on the most vulnerable patients (30,36).

We found important racial/ethnic and economic differences in the prevalence of CRN. The non-Hispanic Asian population was the only racial/ethnic group with significantly lower odds of reporting CRN in the nonelderly group, even after adjusting for income and insurance status, as noted in past literature (37). Between 2010 and 2016, there were large gains in insurance coverage among the nonelderly population across racial/ethnic groups; however, racial/ethnic minorities remained more likely to be uninsured, most notably Native Americans, Hispanics, and non-Hispanic Blacks. Non-Hispanic Asians had lower insurance rates by 2018 (38). Similarly, racial disparities in income and poverty were more prominent among Hispanic and non-Hispanic Black households, while non-Hispanic Asians had the highest median household incomes and poverty rates similar to those of non-Hispanic Whites (39). Furthermore, women were more likely to report CRN regardless of age. Sex disparity in CRN is well documented among patients with ASCVD (18), diabetes (11,40,41), and cancer (42). Among adult individuals with diabetes reporting CRN in this study, 60% were women, and female sex was significantly associated with CRN. Although women are less likely than men to be uninsured, more women are enrolled in Medicaid than men, and insurance plans differ significantly by sex (43). In addition, women are less likely than men to have coverage through their own employer and more likely to obtain coverage through their spouse and more likely to have higher OOP expenses, and low-income women, women of color, and noncitizen women are at greater risk of being uninsured (43,44). These findings add to the growing literature indicating the role of existing social determinants of health in widening socioeconomical disparities in the medical care of diabetes (45,46).

Despite its cross-sectional design, this study together with the previous body of literature in this space has important implications for potential interventions at the individual, provider, and policy levels. First, our findings further reinforce the importance of screening of social determinants of health, with special attention to characteristics associated with CRN, because some groups are affected disproportionately as a result of inequitable resource allocation. Health disparities in diabetes, in general, are prominent among racial, ethnic, geographic, and socioeconomic groups, particularly families and individuals with the lowest incomes and most limited resources (47).

Table 3—Prevalence of cost-reducing behaviors among adults with diabetes, with or without CRN, from the NHIS, 2013–2018

	Adults with diabetes			
	Nonelderly (age 18–64 years)		Elderly (age ≥65 years)	
	No CRN	CRN	No CRN	CRN
Asked doctor for lower-cost medication	19.7 (18.5, 21.0)	71.4 (68.6, 74.1)	18.3 (17.2, 19.3)	71.3 (66.8, 75.8)
Bought prescription drugs from another country	1.5 (1.1, 1.9)	4.3 (3.1, 5.4)	1.4 (1.1, 1.7)	5.8 (3.5, 8.0)
Used alternative therapies	2.7 (2.3, 3.2)	16.6 (14.6, 18.6)	1.4 (1.1, 1.7)	11.8 (8.5, 15.0)

Data given as weighted % (95% CI). $P < 0.05$ for all comparisons.

Providers should discuss costs with patients when choosing a medical treatment. Ideally, cost minimization approaches should be explored in all patients with diabetes, particularly among those most vulnerable to financial hardship and CRN, while still providing them with the highest-quality, equitable care. Second, policy interventions should aim at attenuating the continuous rise in price of diabetes drugs and ensure equitable pricing; these strategies could help reduce OOP costs and influence patients' decisions regarding cost-reducing behaviors, such as purchasing prescription medications from another country. In addition, enhancing current health care coverage could be a venue for improved adherence to medications in nonelderly adults, leading to enhanced health outcomes in the ever-increasing population of patients with diabetes in the U.S.

Lastly, it is important to note that perhaps the most effective intervention to prevent CRN in patients with diabetes is the primordial prevention of diabetes itself. This can result in dramatic cost savings for patients and health care systems, and efforts should be made to curb the concerning trends in the prevalence of diabetes recently observed in our country.

The current study has a few limitations. First, our results are based on survey data in which information biases, such as recall bias or social desirability bias, may have affected the results. Second, diabetes was based on self-report. Although self-report of conditions can be potentially inaccurate, the prevalence of self-reported diabetes in the NHIS is consistent with the national rates of diagnosed diabetes reported by the National Diabetes Statistic Report (1). Third, the survey did not include a nonadherence question specific to using diabetes medications, and CRN includes both diabetes and other medications. Finally, we were unable to establish causality because of the cross-sectional nature of this study.

Medication nonadherence resulting from cost is frequently reported among individuals with diabetes living in the U.S., particularly in nonelderly adults. Greater attention to CRN vulnerability and policy interventions aimed at reducing medication costs and enhancing health care coverage may help improve adherence to medications, and potentially health outcomes, in the ever-increasing population of individuals with diabetes in the U.S.

Funding. K.N. is supported in part by the Jerold B. Katz Academy of Translational Research.
Duality of Interest. K.N. is on the advisory boards of Amgen, Novartis, and Medicine Company. No other potential conflicts of interest relevant to this article were reported.
Author Contributions. M.B.T., J.V.-E., T.Y., M.C.-A., and K.N. designed the study. M.B.T., J.V.-E., T.Y., and C.C. wrote the manuscript. J.V.-E. prepared the statistical analysis. M.B.T. prepared the figures. R.K., K.V.P., H.J.R.A., G.S., E.M., M.C.-A., and K.N. reviewed and edited the manuscript. All authors reviewed and revised the manuscript and agreed to the submission of the final manuscript J.V.-E. and K.N. are the guarantors of this work and, as such, had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

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