

**ORIGINAL RESEARCH**

# Cumulative Burden of Financial Hardship From Medical Bills Across the Spectrum of Diabetes Mellitus and Atherosclerotic Cardiovascular Disease Among Non-Elderly Adults in the United States

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**BACKGROUND:** Atherosclerotic cardiovascular disease (ASCVD) has a strong association with diabetes mellitus (DM), accounting for approximately two thirds of deaths in this patient population. Many individuals with ASCVD and DM are vulnerable to financial hardship associated with treatment-related expenses. Therefore, we examined the burden of financial hardship from medical bills across the spectrum of ASCVD status with and without DM.

**METHODS AND RESULTS:** Using data from the National Health Interview Survey from 2013 to 2017, we used logistic regression analysis to examine the association of ASCVD and DM status with financial hardship and an inability to pay medical bills from a representative sample of non-elderly adults in the United States. Our study population consisted of 121 672 individuals. Approximately 3.1% of the weighted population had ASCVD, 5.6% had DM, and 1.3% had both ASCVD and DM. Nearly 50% of individuals with ASCVD and DM reported financial hardship from medical bills (23% being unable to pay medical bills at all), whereas ≈28% of those with neither ASCVD nor DM reported financial hardship from medical bills (8% being unable to pay medical bills at all). Individuals with concurrent ASCVD and DM had the highest relative odds of expressing an inability to pay at all when compared with those with neither condition (odds ratio, 2.69; 95% CI, 2.21–3.28).

**CONCLUSIONS:** Individuals with concurrent ASCVD and DM are at a disproportionately high risk of being unable to pay their medical bills. The findings provide strong evidence for developing more effective public health policies that protect vulnerable populations from financial hardship.

**Key Words:** atherosclerotic cardiovascular disease ■ diabetes mellitus ■ financial hardship ■ medical bills ■ outcomes

**A**therosclerotic cardiovascular disease (ASCVD) is the leading cause of morbidity and mortality among individuals with diabetes mellitus (DM) and the largest contributor to direct and indirect healthcare costs associated with DM. Individuals with DM have a 2- to 3-fold increased risk for ASCVD.<sup>1,2</sup> Despite a national

healthcare system with access to statins and other lipid-lowering medications, along with anti-hypertensive and anti-hyperglycemic therapies, adverse cardiovascular events rates remain higher for patients with DM than for those without DM.<sup>3,4</sup> With nearly 1-in-4 non-elderly individuals devoting more than half of their total out-of-pocket

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## CLINICAL PERSPECTIVE

### What Is New?

- In a nationally representative sample of non-elderly adults in the United States, ≈1-in-2 individuals with concurrent atherosclerotic cardiovascular disease and diabetes mellitus reported financial hardship from medical bills.
- Among patients with both atherosclerotic cardiovascular disease and diabetes mellitus, representing >2.3 million individuals in the United States, nearly 1-in-4 were unable to pay their medical bills at all.

### What Are the Clinical Implications?

- Considering significant financial burden experienced by individuals with atherosclerotic cardiovascular disease and diabetes mellitus, shared decision-making processes should leverage patients' insurance coverage and financial circumstances.

## Nonstandard Abbreviations and Acronyms

<b>ASCVD</b>	atherosclerotic cardiovascular disease
<b>DM</b>	diabetes mellitus
<b>NHIS</b>	National Health Interview Survey

healthcare spending to prescription drugs,<sup>5</sup> this high resource utilization may translate into higher financial burden among patients with ASCVD and DM as concurrent chronic diseases.

Recent research has shown that patients with either ASCVD or DM have high medical-related expenses that can put them at risk for financial toxicity.<sup>6</sup> Even among those with adequate health insurance, individuals with ASCVD are inadequately protected from financial hardship because of insurance- and treatment-related expenses.<sup>7</sup> More than 45% of non-elderly adults, or 3.9 million individuals, with ASCVD have reported financial hardship from medical bills with nearly 19% being unable to pay their medical bills at all.<sup>6</sup> In terms of DM, the estimated national cost of DM in 2017 was ≈\$327 billion, of which 73% represented direct healthcare expenditures attributable to DM.<sup>8</sup> On average, people with diagnosed DM have medical expenditures ≈2.3 times higher than what they would be in the absence of DM or an average out-of-pocket expenditure of over \$1800 per year.<sup>8,9</sup> Nearly 25% of individuals with DM are part of a family that spends >10% on health-related expenses<sup>10</sup> and 41% of DM patients reporting living in families with financial hardship from

medical bills (15.6% being unable to pay medical bills at all).<sup>11</sup> Individuals with DM who report financial hardship from medical bills have recently been shown to express higher rates of high financial distress, food insecurity, cost-related medication non-adherence, and foregone or delayed care.<sup>11</sup>

Although healthcare costs and resource utilization have been shown to be highest among individuals diagnosed with concurrent DM and ASCVD,<sup>12</sup> the cumulative burden of financial hardship from medical bills reported by individuals with both chronic conditions remains unknown. With more than one quarter of adults having multiple chronic conditions, understanding current trends in a nationally representative sample of non-elderly adults in the United States may provide insight into the prevalence of financial burden and its consequences, including cost-related medication nonadherence.<sup>13,14</sup> Therefore, using data from the National Health Interview Survey (NHIS), we compared the prevalence of financial hardship and an inability to pay medical bills among individuals with and without ASCVD and DM.

## METHODS

All NHIS data and materials have been made publicly available by the Centers of Disease Control and Prevention and can be accessed at <https://www.cdc.gov/nchs/nhis/index.htm>.

### Study Design

We used 5 years (2013–2017) of pooled data from the NHIS. The NHIS is led by the National Center for Health Statistics/Centers for Disease Control and Prevention database and is developed from annual cross-sectional surveys disseminated nationwide.<sup>15</sup> These surveys incorporate multi-stage sampling to provide estimates on the population of the United States. The NHIS questionnaire is distributed into 4 central sections: Household Composition, Family Core, Sample Child Core, and Sample Adult Core. The Household Composition file contains data pertaining to basic and relationship characteristics about all individuals included in the given household. Additionally, the Family Core file collects various sociodemographic information along with fundamental markers of health status, health insurance coverage, and access to healthcare services. One child and one adult are ultimately selected at random from each family to collect more detailed information contributing to the Sample Child Core and Sample Adult Core files, respectively. In this study, we used the in-depth data from the Sample Adult Core file, supplemented with covariates collected in other files, to analyze factors associated with financial hardship from medical bills in the US adult

population. Since NHIS data are publicly available as de-identified records, this study was exempt from review by the Yale University Institutional Review Board Committee.<sup>16</sup>

## Study Population

To classify individuals with an ASCVD status, we used a self-reported diagnosis of coronary or cerebrovascular disease. Individuals were included if they reported having coronary artery disease (“Yes” to any of the following questions: “Have you ever been told by a doctor or other health professional that you had ... coronary heart disease?”, “... angina, also called angina pectoris?”, “... a heart attack (also called a myocardial infarction)?”, and/or “... stroke”). Additionally, we used self-reported measures to determine individuals with DM. Specifically, individuals were included if they reported having DM (“Yes” to the following questions: *Other than during pregnancy, have you ever been told by a doctor or other health professional that you have diabetes or sugar diabetes?*). We limited our study to focus on non-elderly (18–64 years of age) adults with ASCVD and/or DM to analyze the financial hardship experienced by those who lack financial protections from public insurance.

## Outcome Variables

Individuals who responded “Yes” to any of the following questions were classified as having 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”,* and *“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”.* Additionally, to establish the severity of the financial burden, those who answered “Yes” to the following follow-up question were then classified as “Unable to pay medical bills at all”, what we considered to be the highest degree of financial hardship from medical bills: *“Do you/Does anyone in your family currently have any medical bills that you are unable to pay at all?”*, while the rest of them were classified as “financial hardship from medical bills but able to pay”.

## Covariates

Covariates included in this study were age (18–39 and 40–64 years), sex, family income (middle/high income ( $\geq 200\%$  federal poverty limit) and poor/low-income

(<200% federal poverty limit)), race/ethnicity (non-Hispanic white, non-Hispanic black, non-Hispanic Asian, and Hispanic), insurance status (public, private, and uninsured), education (at least some college education and less than college education), family size (1, 2, and  $\geq 3$ ), region (Northeast, Midwest, South, and West), and number of chronic comorbidities. Chronic comorbidities included emphysema, chronic obstructive pulmonary disease, asthma, gastrointestinal ulcer, cancers, arthritis, and any kind of liver condition or “weak/failing” kidneys, and were categorized as having 0, 1, or  $\geq 2$ .

## Statistical Analysis

We used data from the Integrated Public Use Microdata Series (<http://www.ipums.org>) to correctly calculate variance estimation for nationally representative results, since 5 years of pooled data were used for analysis.<sup>17</sup> Weighted proportions were used to study the prevalence of the baseline characteristics of the study population and the outcomes of interest which were compared using  $\chi^2$  analysis across DM and ASCVD status. Unadjusted and adjusted logistic regressions were used to calculate odds ratios (ORs) and 95% CI to evaluate the association of financial hardship from medical bills and inability to pay bills across DM and ASCVD status. For all statistical analyses,  $P$  value of  $<0.05$  was considered statistically significant. All analyses were conducted using Stata, version 15.1 (StataCorp, LP, College Station, Texas, USA).

## RESULTS

Our study population consisted of 121 672 individuals (aged 18–64 years), 74% of the total cohort surveyed by NHIS from 2013 to 2017. This sample represented the 193 million non-elderly adults in the United States (Table 1). The mean age of the sample was  $42 \pm 13.4$  years and nearly 51% were women. Overall, 6.9% of the weighted study population had DM and 4.4% had ASCVD. On further stratification, 3.1% had ASCVD alone, 5.6% had diabetes mellitus alone, and 1.3% of the study population had both ASCVD and DM. Individuals with neither condition accounted for the remaining 90% of the study population. When comparing individuals with DM and ASCVD alone, a greater proportion of those with ASCVD reported poor/low family income and  $\geq 2$  comorbid conditions, whereas a greater proportion of those with DM reported having  $\geq 3$  family members in the household.

Individuals with DM alone reported lower, but not statistically significant, rates of financial hardship from medical bills and an inability to pay bills at all

**Table 1. General Characteristics Among Non-Elderly Adults by DM and ASCVD Status, From the National Health Interview Survey, 2013 to 2017**

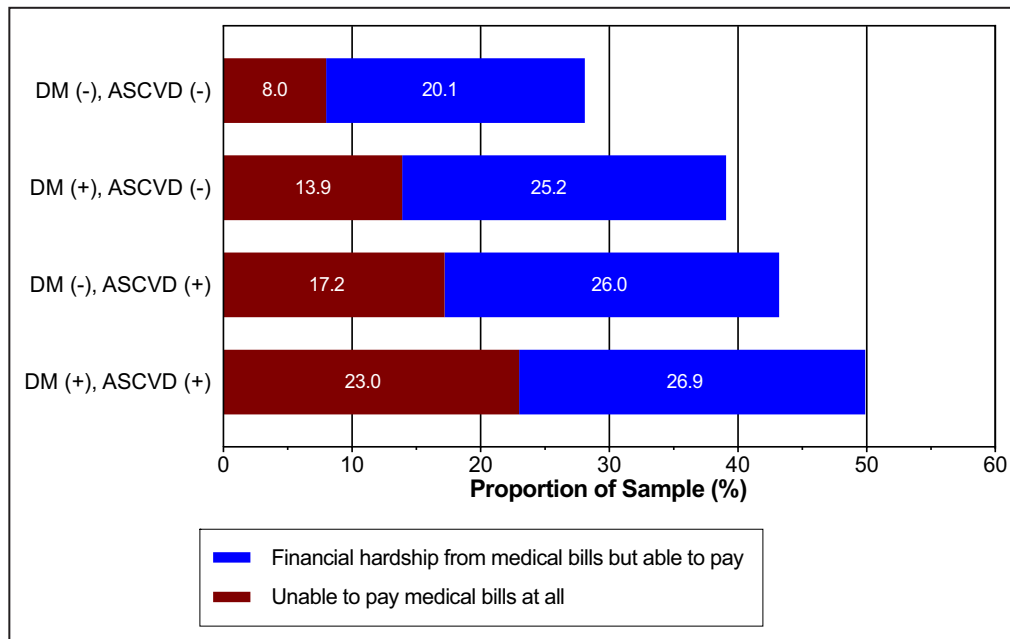
	Total	DM (-), ASCVD (-)	DM (+), ASCVD (-)	DM (-), ASCVD (+)	DM (+), ASCVD (+)	P Value
Sample, N	121 672	108 516	7251	4189	1716	
Weighted sample, n (weighted %)	192 524 324	173 490 379 (90%)	10 709 141 (5.6%)	5 905 548 (3.1%)	2 419 256 (1.3%)	
Age category, n (weighted %)						<0.001
18 to 39 y	55 252 (47.7)	53 541 (51.4)	1051 (15.2)	599 (15.7)	61 (4.8)	
40 to 64 y	66 420 (52.3)	54 975 (48.6)	6200 (84.8)	3590 (84.3)	1655 (95.2)	
Sex, n (weighted %)						<0.001
Men	56 203 (49.1)	49 749 (48.7)	3275 (49.5)	2253 (57.6)	926 (57.1)	
Women	65 469 (50.9)	58 767 (51.3)	3976 (50.5)	1936 (42.3)	790 (42.9)	
Race/ethnicity, n (weighted %)						<0.001
Non-Hispanic white	75 156 (63.4)	67 405 (63.6)	3960 (57.7)	2797 (70.4)	994 (60.0)	
Non-Hispanic black	16 647 (13.0)	14 176 (12.5)	1399 (17.3)	690 (14.8)	382 (19.9)	
Non-Hispanic Asian	7337 (6.1)	6870 (6.4)	317 (5.3)	102 (2.6)	48 (3.3)	
Hispanic	20 845 (17.5)	18 701 (17.5)	1380 (19.7)	516 (12.2)	248 (16.8)	
Family size, n (weighted %)						<0.001
1	36 803 (17.1)	32 082 (16.8)	2408 (18.1)	1596 (22.2)	717 (24.5)	
2	34 504 (28.8)	30 117 (27.9)	2373 (35.0)	1415 (38.3)	599 (38.0)	
≥3	50 365 (54.1)	46 317 (55.3)	2470 (46.9)	1178 (39.5)	400 (37.5)	
Family income, n (weighted %)						<0.001
Middle/high-income	72 493 (68.5)	66 119 (69.7)	3796 (60.8)	1915 (55.6)	663 (48.7)	
Poor/low-income	41 842 (31.5)	35 773 (30.3)	3063 (39.2)	2048 (44.4)	958 (51.3)	
Insurance status, n (weighted %)						<0.001
Insured	102 348 (85.4)	90 830 (85.2)	6347 (87.6)	3587 (86.5)	1584 (91.5)	
Uninsured	18 732 (14.6)	17 137 (14.8)	882 (12.4)	584 (13.5)	129 (8.5)	
Education, n (weighted %)						<0.001
Some college or higher	77 769 (64.1)	71 016 (65.4)	3830 (53.4)	2122 (51.8)	801 (48.1)	
HS/GED or less than HS	43 479 (35.9)	37 132 (34.6)	3385 (46.6)	2053 (48.2)	909 (51.9)	
Region, n (weighted %)						<0.001
Northeast	19 285 (17.4)	17 353 (17.6)	1067 (16.0)	621 (15.4)	244 (14.9)	
Midwest	26 289 (22.5)	23 422 (22.3)	1553 (22.7)	945 (24.3)	369 (24.6)	
South	43 400 (36.5)	38 066 (36.1)	2843 (39.6)	1712 (41.4)	779 (44.9)	
West	32 698 (23.6)	29 675 (24.0)	1788 (21.7)	911 (18.9)	324 (15.6)	
Comorbidities, n (weighted %)						<0.001
0	78 516 (66.3)	73 616 (69.3)	3078 (44.2)	1439 (36.2)	383 (24.8)	
1	29 933 (24.0)	25 732 (23.1)	2413 (33.8)	1284 (34.5)	504 (30.3)	
≥2	13 223 (9.6)	9168 (7.6)	1760 (22.0)	1466 (32.3)	829 (44.9)	

ASCVD indicates atherosclerotic cardiovascular disease; CRF, cardiovascular risk factor; HS, high school; and GED, general equivalency diploma.

when compared with individuals with ASCVD alone (financial hardship from medical bills but able to pay: 39.1% versus 43.2% and unable to pay at all: 13.9% versus 17.2%). Furthermore, 49.9% of individuals with both ASCVD and DM reported having financial hardship from medical bills (23% being unable to pay medical bills at all), whereas 28.1% of those without both ASCVD and DM reported financial hardship from medical bills (8% being unable to pay medical bills at all) (Figure 1). There were significant but minimal differences in the prevalence of financial hardship from

medical bills but able to pay across DM and ASCVD status.

Table 2 depicts the prevalence of financial hardship from medical bills among the covariates across DM and ASCVD status. A notably higher prevalence of both financial hardship from medical bills was demonstrated among individuals between aged 18 and 39 years, without insurance, and with poor/low family income, ≥3 family members in the household, or ≥2 comorbid conditions. Similarly, the prevalence of being unable to pay at all was much higher among the



**Figure 1. Proportion of financial hardship from medical bills and inability to pay at all by diabetes mellitus and atherosclerotic cardiovascular disease status among non-elderly adults, from the National Health Interview Survey, 2013 to 2017.**

ASCVD indicates atherosclerotic cardiovascular disease; and DM, diabetes mellitus.

above mentioned characteristics (Table 3). In regard to sociodemographic variations among individuals with both conditions, we found that 29.7% of non-Hispanic black individuals with concurrent DM and ASCVD reported an inability to pay their medical bills at all, compared with 22.4% of non-Hispanic white individuals. Moreover, our findings showed that 52.8% of uninsured individuals with both ASCVD and DM were unable to pay their medical bills at all, compared with 20.2% among individuals with insurance coverage.

After adjusting for known covariates, individuals with concurrent ASCVD and DM had the highest relative odds of expressing an inability to pay at all when compared with those with neither condition (OR, 2.69; 95% CI, 2.21–3.28). Additionally, individuals with either ASCVD or DM had higher odds of being unable to pay when compared with those with neither condition (ASCVD: OR, 1.97; 95% CI, 1.72–2.25; DM: OR, 1.70; 95% CI, 1.52–1.91) (Figure 2). On stratified analysis to control for effect-modification, similar trends were seen in the odds of financial hardship from medical bills and inability to pay medical bills (Tables S1 and S2).

## DISCUSSION

In a nationally representative sample of non-elderly adults in the United States, we found that individuals with both ASCVD and DM experienced nearly a 3-fold increase in the adjusted odds of reporting an inability to pay their medical bills at all when compared with

individuals with neither ASCVD nor DM. Additionally, those with either ASCVD or DM were found to express higher relative levels of financial hardship from medical bills when compared with those with neither condition. A higher prevalence of both financial hardship and an inability to pay medical bills at all were demonstrated among individuals with a low family income as well as those without insurance coverage.

Because of rising healthcare costs, the financial burden sustained by patients and their families from medical bills has gained considerable attention nationwide. Financial hardship has been reported in various chronic conditions,<sup>18,19</sup> particularly with regards to cancer.<sup>20–22</sup> Several recent studies, however, have assessed trends in financial hardship and its consequences among individuals with ASCVD.<sup>6,17,23,24</sup> Khera and colleagues, for instance, reported that among families with low-income and a member that has ASCVD, 1-in-4 suffer from high financial burden, while 1-in-10 suffer from catastrophic financial burden, defined as expenses beyond financial means.<sup>25</sup> Additionally, research from Valero-Elizondo et al found that >45% of non-elderly adults, or 3.9 million individuals, with ASCVD report financial hardship from medical bills and nearly 19% have reported being unable to pay their medical bills at all.<sup>6</sup> These results, also using NHIS data, correspond with our findings that 43.2% of individuals with ASCVD alone report financial hardship from medical bills, and that this burden disproportionately affects racial/ethnic minorities along with uninsured individuals, and



**Table 2. Prevalence of Overall Financial Hardship, Among Non-Elderly Adults by DM and ASCVD Status, From the National Health Interview Survey, 2013 to 2017**

	Total	DM (-), ASCVD (-)	DM (+), ASCVD (-)	DM (-), ASCVD (+)	DM (+), ASCVD (+)	P Value
Sample, n	121 672	108 516	7251	4189	1716	
Weighted sample, (weighted %)	192 524 324	173 490 379 (90%)	10 709 141 (5.6%)	5 905 548 (3.1%)	2 419 256 (1.3%)	
Age category, n (weighted %)						
18 to 39 y	15 588 (30.1)	14 903 (29.5)	480 (44.9)	274 (45.0)	31 (64.1)	<0.001
40 to 64 y	19 190 (29.2)	14 561 (26.7)	2312 (38.1)	1527 (42.8)	790 (49.2)	<0.001
Sex, n (weighted %)						
Men	14 676 (27.9)	12 157 (26.4)	1178 (36.3)	907 (41.1)	434 (47.2)	<0.001
Women	20 102 (31.3)	17 207 (29.7)	1614 (41.9)	894 (46.0)	387 (53.5)	<0.001
Race/Ethnicity, n (weighted %)						
Non-Hispanic white	21 371 (29.3)	18 122 (27.8)	1534 (39.5)	1236 (44.3)	479 (50.3)	<0.001
Non-Hispanic black	5759 (36.2)	4657 (34.6)	606 (45.1)	303 (45.2)	193 (51.9)	<0.001
Non-Hispanic Asian	956 (14.3)	840 (13.1)	70 (18.6)	26 (30.3)	20 (54.8)	<0.001
Hispanic	6149 (31.0)	5326 (30.0)	519 (39.2)	195 (35.9)	109 (45.2)	<0.001
Family size, n (weighted %)						
1	8187 (21.3)	6382 (18.8)	855 (35.5)	642 (39.6)	308 (42.8)	<0.001
2	9528 (26.6)	7727 (24.6)	908 (36.6)	601 (41.4)	292 (46.0)	<0.001
≥3	17 063 (33.9)	15 255 (32.7)	1029 (42.5)	558 (46.8)	221 (58.5)	<0.001
Family income, n (weighted %)						
Middle/high-income	18 781 (27.0)	16 399 (25.9)	1347 (35.7)	730 (38.1)	305 (47.9)	<0.001
Poor/low-income	14 360 (36.5)	11 571 (34.5)	1320 (45.7)	993 (50.7)	476 (63.0)	<0.001
Insurance status, n (weighted %)						
Insured	27 138 (27.6)	22 668 (26.0)	2294 (36.6)	1451 (41.2)	725 (48.1)	<0.001
Uninsured	7523 (42.0)	6593 (40.4)	491 (57.8)	345 (56.5)	94 (69.0)	<0.001
Education, n (weighted %)						
Some college or higher	20 271 (26.8)	17 570 (25.5)	1458 (37.9)	872 (40.6)	371 (47.4)	<0.001
HS/GED or less than HS	14 401 (34.5)	11 709 (33.0)	1324 (40.5)	922 (46.0)	446 (52.0)	<0.001
Region, n (weighted %)						
Northeast	4620 (22.7)	3927 (21.6)	347 (30.0)	245 (34.7)	101 (46.2)	<0.001
Midwest	8204 (33.5)	6933 (31.8)	680 (47.2)	402 (44.3)	189 (62.0)	<0.001
South	13 679 (33.7)	11 273 (31.9)	1191 (42.7)	809 (48.8)	406 (55.8)	<0.001
West	8275 (24.7)	7231 (23.8)	574 (30.9)	345 (36.2)	125 (33.3)	<0.001
Comorbidities, n (weighted %)						
0	19 053 (25.9)	17 373 (25.2)	1023 (33.5)	495 (35.3)	162 (45.3)	<0.001
1	9871 (33.6)	8115 (32.0)	947 (41.2)	560 (42.8)	249 (51.7)	<0.001
≥2	5854 (44.9)	3876 (42.5)	822 (47.4)	746 (52.3)	410 (51.3)	<0.001

ASCVD indicates atherosclerotic cardiovascular disease; CRF, cardiovascular risk factor; HS, high school; and GED, general equivalency diploma.

those with a lower relative family income and education status.

To our knowledge, this is the first study that has examined self-reported financial hardship from medical bills and an inability to pay medical bills across the spectrum of ASCVD and DM status as concurrent chronic conditions. Results from our study also coincide with recent literature that has assessed the burden and consequences of financial toxicity among non-elderly adults with DM. Caraballo and colleagues found that, among their sample of nearly 9000 individuals with

DM, representing 13.1 million people annually across the United States, that 41.1% were part of families facing financial hardship from medical bills where 15.6% were unable to pay their bills at all.<sup>11</sup> In our study, 39.1% of non-elderly adults with DM alone faced financial hardship from medical bills. Our findings also align with the outcomes reported by Feldman and colleagues, who demonstrated that the diagnosis of DM yields significantly lower healthcare expenditures and resource utilization when compared with ASCVD and that the highest expenditure rates were among individuals with

**Table 3. Prevalence of an Inability to Pay Medical Bills Among Non-Elderly Adults by DM and ASCVD Status, From the National Health Interview Survey, 2013–2017**

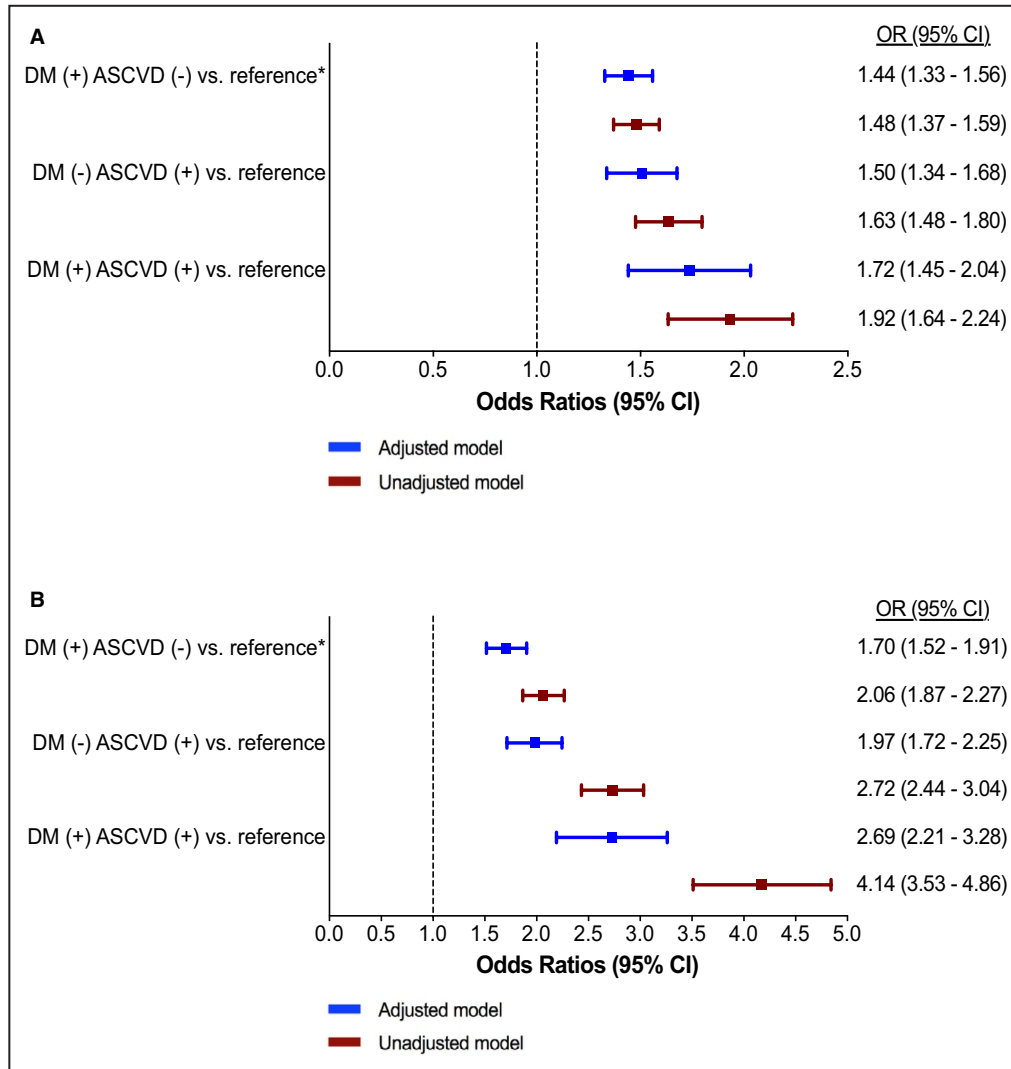
	Total	DM (-), ASCVD (-)	DM (+), ASCVD (-)	DM (-), ASCVD (+)	DM (+), ASCVD (+)	P Value
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Weighted sample, (weighted %)	192 524 324	173 490 379 (90%)	10 709 141 (5.6%)	5 905 548 (3.1%)	2 419 256 (1.3%)	
Age category, n (weighted %)						
18 to 39 y	4943 (9.4)	4578 (9.0)	241 (20.0)	133 (19.6)	18 (39.3)	<0.001
40 to 64 y	5836 (8.4)	3970 (6.9)	840 (12.8)	657 (16.8)	369 (22.2)	<0.001
Sex, n (weighted %)						
Men	4352 (8.0)	3359 (7.2)	435 (12.6)	370 (15.5)	188 (19.2)	<0.001
Women	6427 (9.7)	5189 (8.7)	619 (15.2)	420 (19.6)	199 (28.1)	<0.001
Race/Ethnicity, n (weighted %)						
Non-Hispanic white	5694 (7.6)	4498 (6.8)	498 (12.3)	488 (15.4)	210 (22.4)	<0.001
Non-Hispanic black	2575 (15.9)	1977 (14.6)	301 (21.7)	186 (27.7)	111 (29.7)	<0.001
Non-Hispanic Asian	209 (2.8)	172 (2.5)	17 (3.0)	13 (11.2)	7 (23.6)	<0.001
Hispanic	2093 (10.1)	1749 (9.5)	206 (14.7)	88 (15.7)	50 (17.5)	<0.001
Family size, n (weighted %)						
1	2841 (7.2)	2018 (5.8)	351 (14.5)	318 (18.6)	154 (21.7)	<0.001
2	2870 (7.8)	2184 (6.7)	322 (12.7)	234 (15.1)	130 (21.2)	<0.001
≥3	5068 (10.0)	4346 (9.3)	381 (14.7)	238 (18.4)	103 (25.8)	<0.001
Family income, n (weighted %)						
Middle/high-income	3648 (5.3)	3027 (4.8)	312 (8.0)	208 (9.7)	101 (17.8)	<0.001
Poor/low-income	6649 (17.1)	5139 (15.7)	691 (23.7)	552 (27.3)	267 (29.1)	<0.001
Insurance status, n (weighted %)						
Insured	7093 (6.9)	5431 (6.1)	774 (11.6)	572 (14.6)	316 (20.2)	<0.001
Uninsured	3646 (20.2)	3082 (18.9)	277 (30.7)	217 (34.4)	70 (52.8)	<0.001
Education, n (weighted %)						
Some college or higher	5275 (6.7)	4293 (6.0)	478 (11.8)	353 (14.8)	151 (19.5)	<0.001
HS/GED or less than HS	5474 (12.7)	4232 (11.7)	573 (16.5)	435 (19.8)	234 (26.3)	<0.001
Region, n (weighted %)						
Northeast	1368 (6.5)	1101 (6.0)	121 (9.1)	96 (11.6)	50 (22.1)	<0.001
Midwest	2223 (8.6)	1779 (7.8)	226 (15.4)	151 (14.7)	67 (18.6)	<0.001
South	4949 (11.8)	3829 (10.7)	501 (16.8)	396 (22.4)	223 (29.2)	<0.001
West	2239 (6.2)	1839 (5.6)	206 (10.6)	147 (13.5)	47 (13.2)	<0.001
Comorbidities, n (weighted %)						
0	5253 (6.9)	4661 (6.6)	337 (10.0)	187 (13.6)	68 (18.8)	<0.001
1	3136 (10.5)	2443 (9.5)	359 (15.7)	231 (15.3)	103 (21.4)	<0.001
≥2	2390 (17.7)	1444 (15.6)	358 (19.1)	372 (24.2)	216 (26.5)	<0.001

ASCVD indicates atherosclerotic cardiovascular disease; CRF, cardiovascular risk factor; HS, high school; and GED, general equivalency diploma.

concurrent ASCVD and DM.<sup>12</sup> Though not statistically significant, we found that individuals with ASCVD alone experienced greater financial hardship along with an inability to pay their medical bills at all than those with DM alone, when compared with the reference.

Lack of health insurance and lower family income are determinants of health accepted to predispose an individual or household to financial hardship from medical bills.<sup>7,25</sup> Poor overall health with greater comorbidities, lower income, and lack of health insurance have been shown to contribute to difficulty

paying for health care among non-elderly adults in the United States.<sup>26</sup> Among individuals with ASCVD, a recent study found associations between health-related quality of life, psychological distress, risk of depression, and self-perception of health from the financial burden.<sup>23</sup> In our study, we exhibited that a higher prevalence of financial hardship and an inability to pay medical bills among low income and uninsured individuals were consistent across the spectrum of ASCVD and DM status. However, it is worthwhile to note that even among those with



**Figure 2. Odds ratios of financial hardship from medical bills by diabetes mellitus and atherosclerotic cardiovascular disease status among non-elderly adults in the United States, from the National Health Interview Survey, 2013 to 2017.**

**A**, Odds ratios represent financial hardship from medical bills, but able to pay. **B**, Odds ratios represent an inability to pay medical bills at all. Adjusted models take into account age, sex, race/ethnicity, geographic region, comorbidities, family size, family income, education, and insurance status. \*Reference group includes non-elderly adults without either ASCVD or DM. ASCVD indicates atherosclerotic cardiovascular disease; DM, diabetes mellitus; OR, odds ratio.

adequate health insurance, many individuals were inadequately safeguarded from the financial hardship associated with insurance- and treatment-related expenses from these conditions both together and on their own. This study affirms the need to mitigate the long-term effects of financial toxicity, especially among those with a low income or who are uninsured.

Future studies are needed to assess the underlying differences in financial burden between ASCVD and DM and may further stratify financial hardship status by healthcare expenditures including outpatient and institutional care as well as by medications such as insulin for DM. Moreover, additional research is needed to further explore potential explanations for

these trends and their consequences, particularly regarding financial toxicity among younger adults aged 18 to 39 years with concurrent chronic conditions. Though our results affirm that insurance coverage may be insufficient in protecting an individual and his or her family from financial toxicity, lower relative rates of insurance coverage among younger adults may, at least in part, help explain the observed differences in reported financial hardship and an inability to pay medical bills among those aged 18 to 39 years.<sup>27</sup>

The results of our study should be interpreted considering certain limitations. First, information pertaining to the study variables was obtained through self-reported surveys, opening the potentiality for



recall bias. Though objective questions and alternative framing methods could have added reliability to measures of financial hardship, self-reported measures of financial burden have been used extensively in previous studies and have been shown to correspond to objective measures of out-of-pocket expenditures.<sup>28</sup> Second, the diagnoses of ASCVD and DM were based on self-report and were not validated with medical records, thus our results and weighted disease prevalence measures may be subject to misclassification bias. An underestimation of the true national prevalence of DM and ASCVD status is plausible. However, despite self-reported ASCVD and DM, our findings are similar to other previously reported national estimates.<sup>29,30</sup> Lastly, because of the cross-sectional nature of the NHIS, causality cannot be established with a plausible reverse causation and the risk for residual confounding, even after adjusting for all known confounders, cannot be disregarded.

## CONCLUSIONS

Individuals with concurrent ASCVD and DM are at an elevated risk of experiencing financial hardship from medical bills, including being unable able to pay medical bills at all when compared to those with ASCVD or DM or neither. Our findings provide strong evidence for clinicians to prevent and manage DM and ASCVD concurrently while leveraging patients' financial circumstances in shared decision making processes, highlights the need for effective public health policies that protect vulnerable populations from financial hardship, and strengthens the notion that insurance coverage may not be sufficient in protecting an individual and their family from financial toxicity.

## ARTICLE INFORMATION

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## Supplementary Materials

Tables S1–S2

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# **SUPPLEMENTAL MATERIAL**

**Table S1. Predictors of Financial Hardship among Non-Elderly Adults by DM and ASCVD status, from the National Health Interview Survey, 2013-17.**

	DM (-), ASCVD (-)	DM (+), ASCVD (-)	DM (-), ASCVD (+)	DM (+), ASCVD (+)
	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
<b>Age Category</b>				
18-39	<i>Reference</i>	1.46 (1.15, 1.86)	1.26 (0.93, 1.72)	1.74 (0.72, 4.23)
40-64		1.42 (1.30, 1.55)	1.51 (1.35, 1.70)	1.66 (1.40, 1.98)
<b>Sex</b>				
Male	<i>Reference</i>	1.46 (1.32, 1.63)	1.52 (1.31, 1.76)	1.54 (1.20, 1.99)
Female		1.50 (1.35, 1.66)	1.54 (1.32, 1.80)	1.86 (1.44, 2.40)
<b>Race/Ethnicity</b>				
Non-Hispanic White	<i>Reference</i>	1.45 (1.31, 1.60)	1.63 (1.43, 1.60)	1.61 (1.29, 2.03)
Non-Hispanic Black		1.43 (1.16, 1.76)	1.12 (0.82, 1.51)	1.66 (1.15, 2.39)
Non-Hispanic Asian		1.52 (0.99, 2.34)	2.12 (0.97, 4.61)	6.34 (2.49, 16.13)
Hispanic		1.37 (1.13, 1.68)	1.10 (0.81, 1.49)	1.83 (1.14, 2.93)
<b>Family Size</b>				
1	<i>Reference</i>	1.51 (1.32, 1.73)	1.56 (1.30, 1.87)	1.57 (1.23, 2.00)
2		1.43 (1.24, 1.63)	1.58 (1.33, 1.88)	1.43 (1.11, 1.86)
≥ 3		1.40 (1.22, 1.59)	1.38 (1.14, 1.68)	2.07 (1.49, 2.90)
<b>Family Income</b>				
Middle/High-Income	<i>Reference</i>	1.50 (1.35, 1.66)	1.54 (1.32, 1.80)	1.86 (1.45, 2.40)

Poor/Low-Income		1.32 (1.13, 1.50)	1.42 (1.19, 1.70)	1.49 (1.16, 1.91)
<b>Insurance Status</b>				
Insured	<i>Reference</i>	1.40 (1.28, 1.53)	1.55 (1.38, 1.75)	1.75 (1.47, 2.09)
Uninsured		1.73 (1.32, 2.26)	1.13 (0.80, 1.58)	1.04 (0.48, 2.26)
<b>Education</b>				
Some College or Higher	<i>Reference</i>	1.55 (1.39, 1.73)	1.55 (1.34, 1.80)	1.96 (1.54, 2.52)
HS/GED or Less than HS		1.30 (1.15, 1.47)	1.43 (1.22, 1.68)	1.52 (1.17, 1.96)
<b>Region</b>				
Northeast		1.53 (1.23, 1.91)	1.69 (1.25, 2.28)	2.10 (1.29, 3.43)
Midwest	<i>Reference</i>	1.71 (1.45, 2.01)	1.47 (1.16, 1.86)	1.92 (1.40, 2.66)
South		1.41 (1.25, 1.58)	1.51 (1.28, 1.78)	1.72 (1.32, 2.25)
West		1.15 (0.94, 1.41)	1.38 (1.07, 1.78)	1.12 (0.73, 1.72)
<b>Comorbidities</b>				
0		1.54 (1.35, 1.75)	1.53 (1.27, 1.85)	2.22 (1.54, 3.19)
1	<i>Reference</i>	1.39 (1.20, 1.61)	1.54 (1.25, 1.88)	2.19 (1.59, 3.00)
≥ 2		1.29 (1.09, 1.54)	1.38 (1.13, 1.67)	1.26 (0.97, 1.63)

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DM, Diabetes Mellitus; ASCVD, atherosclerotic cardiovascular disease; aOR, adjusted odds ratios; CI, confidence interval; HS, high school; GED, general equivalency diploma



**Table S2. Predictors of Inability to Pay Medical Bills among Non-Elderly Adults by DM and ASCVD status, from the National Health Interview Survey, 2013-17.**

	DM (-), ASCVD (-)	DM (+), ASCVD (-)	DM (-), ASCVD (+)	DM (+), ASCVD (+)
	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
<b>Age Category</b>				
18-39	<i>Reference</i>	2.04 (1.57, 2.64)	1.61 (1.12, 2.32)	4.22 (1.60, 11.11)
40-64		1.59 (1.40, 1.80)	1.95 (1.68, 2.25)	2.46 (2.01, 3.01)
<b>Sex</b>				
Male	<i>Reference</i>	1.82 (1.53, 2.16)	2.02 (1.64, 2.48)	2.90 (2.21, 3.81)
Female		1.63 (1.40, 1.88)	1.97 (1.65, 2.36)	2.53 (1.90, 3.36)
<b>Race/Ethnicity</b>				
Non-Hispanic White	<i>Reference</i>	1.65 (1.40, 1.93)	1.99 (1.65, 2.39)	2.85 (2.17, 3.75)
Non-Hispanic Black		1.74 (1.42, 2.15)	2.09 (1.61, 2.72)	2.34 (1.69, 3.24)
Non-Hispanic Asian		0.96 (0.38, 2.42)	2.81 (1.11, 7.09)	21.20 (4.41, 101.96)
Hispanic		1.77 (1.41, 2.21)	1.65 (1.14, 2.40)	2.34 (1.47, 3.70)
<b>Family Size</b>				
1	<i>Reference</i>	1.88 (1.56, 2.26)	2.38 (1.96, 2.89)	2.37 (1.79, 3.14)
2		1.69 (1.38, 2.06)	2.02 (1.62, 2.52)	2.54 (1.84, 3.51)
≥ 3		1.66 (1.41, 1.95)	1.68 (1.32, 2.15)	3.12 (2.13, 4.57)
<b>Family Income</b>				
Middle/High-Income	<i>Reference</i>	1.77 (1.47, 2.13)	2.15 (1.73, 2.67)	4.40 (3.12, 6.22)

Poor/Low-Income		1.60 (1.39, 1.84)	1.79 (1.51, 2.11)	1.88 (1.52, 2.33)
<b>Insurance Status</b>				
Insured	<i>Reference</i>	1.65 (1.44, 1.87)	1.99 (1.70, 2.32)	2.50 (2.01, 3.10)
Uninsured		1.87 (1.47, 2.39)	1.82 (1.34, 2.48)	4.22 (2.32, 7.67)
<b>Education</b>				
Some College or Higher	<i>Reference</i>	1.97 (1.64, 2.37)	2.57 (2.13, 3.11)	3.45 (2.48, 4.78)
HS/GED or Less than HS		1.49 (1.29, 1.72)	1.58 (1.31, 1.89)	2.24 (1.77, 2.83)
<b>Region</b>				
Northeast		1.45 (1.01, 2.09)	1.87 (1.23, 2.84)	3.68 (2.30, 5.92)
Midwest	<i>Reference</i>	2.23 (1.77, 2.81)	1.87 (1.38, 2.54)	2.40 (1.48, 3.90)
South		1.57 (1.35, 1.82)	1.97 (1.65, 2.35)	2.82 (2.16, 3.69)
West		1.71 (1.28, 2.30)	2.25 (1.61, 3.15)	1.94 (1.15, 3.26)
<b>Comorbidities</b>				
0		1.72 (1.45, 2.04)	2.22 (1.74, 2.84)	4.93 (3.18, 7.66)
1	<i>Reference</i>	1.98 (1.61, 2.42)	1.89 (1.49, 2.40)	3.12 (2.21, 4.41)
≥ 2		1.35 (1.09, 1.68)	1.76 (1.41, 2.19)	1.95 (1.47, 2.59)

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DM, Diabetes Mellitus; ASCVD, atherosclerotic cardiovascular disease; aOR, adjusted odds ratios; CI, confidence interval; HS, high school; GED, general equivalency diploma