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Medical Expenditures Associated With Diabetes in Myocardial Infarction and Ischemic Stroke Patients

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Abstract

Introduction: The coexistence of diabetes among people with acute myocardial infarction (AMI) or acute ischemic stroke (AIS) is common. However, little is known about the extent of excess medical expenditures associated with having diabetes among AMI and AIS patients.

Methods: Data on 3,307 AMI patients and 2,460 AIS patients aged ≥18 years from the 2008 to 2014 Medical Expenditure Panel Survey were analyzed. Per capita annual medical expenditures associated with diabetes were separately estimated by healthcare components with generalized linear models and two-part models. Excess expenditure associated with diabetes is the difference between estimated expenditure conditional on having both diabetes and AMI (or AIS) and the estimated expenditure conditional on having AMI (or AIS) but not diabetes. All expenditures were adjusted to 2014 U.S. dollars. The analysis was conducted in 2017.

Results: Per capita annual total excess expenditures associated with diabetes were $5,117 (95% CI=$4,989, $5,243) for AMI patients and $5,734 (95% CI=$5,579, $5,887) for AIS patients. Of the total excess expenditures, prescription drugs accounted for 40% among AMI patients and 42% among AIS patients. Higher expenditures associated with diabetes were explained more by higher volume of utilization than higher per unit expenditures.

Conclusions: Excess expenditures associated with diabetes were substantial among both AMI and AIS patients. These results highlight the needs for both prevention and better management of diabetes among AMI and AIS patients, which in turn may lower the financial burden of treating these conditions.

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INTRODUCTION

Acute myocardial infarction (AMI) and acute ischemic stroke (AIS) are common cardiovascular events that impose a large economic burden on the U.S. healthcare system.[1] The direct medical cost of stroke in the U.S in 2012–2013 has been estimated at $17.9 billion, and medical spending on hospital care of myocardial infarction in 2011 was estimated at $11.5 billion.[1,2]

A notable trend among the population with AMI and AIS is the rising coexistence with diabetes. From 1997 to 2011, the number of U.S. adults aged ≥35 years with either heart disease or stroke and diabetes increased from 4.2 million to 7.6 million.[3] Such coexistence imposes considerable burden on the healthcare system. For AMI and AIS patients, diabetes often leads to worse clinical outcomes, such as recurrent cardiovascular events and longer hospital stays.[4,5] The situation could further escalate, as diabetes incidence is projected to double from 2008 to 2050.[6]

Although the financial burden of diabetes among the general population has been studied, the degree to which medical expenditures burden AMI and AIS patients specifically is not well understood. A recent study in Taiwan found higher hospitalization expenditures for stroke among patients with diabetes than among those without diabetes.[7] However, this study was limited to hospitalization expenditures and did not estimate the excess expenditure associated with diabetes. Although the estimated excess expenditures associated with diabetes among the general population also include cases of AMI and AIS,[8,9] these estimates cannot be directly applied to a specific population with severe health conditions, such as AMI and AIS.

The purpose of this study is to examine medical expenditures associated with diabetes among patients with AMI and AIS in the U.S. Medical expenditures in total and by healthcare components (inpatient stays, emergency room visits, outpatient visits, prescription drugs, and other services) are estimated using nationally representative samples. Such information is important to understand the financial burden of diabetes among patients with AMI and AIS, and to evaluate the benefits of interventions targeted to reducing diabetes and cardiovascular disease (CVD).

METHODS

Study Sample

Data were analyzed from the 2008 to 2014 waves of the Medical Expenditure Panel Survey Household Component Full Year Files (MEPS-HC), a nationally representative survey of the civilian non-institutionalized population in the U.S. The MEPS-HC is sponsored by the Centers for Disease Control and Prevention's National Center for Health Statistics and the Agency for Healthcare Research and Quality. The sampling frame of the MEPS-HC is a subsample of participants in the previous year's National Health Interview Survey. The selection of the subsample of National Health Interview Survey for the MEPS-HC retains national representativeness of the survey, and also enhances the analytical capacity of the MEPS-HC data.[10] MEPS-HC is the most comprehensive data source on national-

level medical care utilizations and expenditures. It also collects extensive individual-level information, including demographic and socioeconomic characteristics, health behaviors, and health status.

A sample with merged information of person–year level data was used for years from 2008 to 2014, which combined the full-year consolidated files and the medical condition files. The study sample consisted of 3,307 U.S. adults aged ≥18 years with AMI and 2,460 with AIS. Women who were pregnant at the time of the survey were excluded (n=5).

Measures

Survey respondents reported healthcare services and prescription drugs usage as well as associated medical conditions within the survey calendar year for each household member. These medical conditions were recorded as verbatim text and then coded by professional coders to the ICD-9-CM codes. For confidentiality reasons, the released ICD-9-CM codes in MEPS-HC contain only the first three digits. These codes were used to identify people with AMI (ICD-9-CM code 410); AIS (ICD-9-CM codes 433, 434, 436); and diabetes (ICD-9-CM code 250).[11-13] Because conditions were defined based on utilization, people with a history of AMI or AIS, but who did not have any medical treatment during the calendar year were not identifiable with the ICD9 codes.[14] Thus, the study identified conditions that were currently treated for each MEPS-HC sample person.

Medical expenditures were measured as the payments for healthcare services, collected from both medical providers and patients' self-report, for each individual within the survey calendar year.[15] Per capita annual total medical expenditures were examined, as well as expenditures for each of the individual healthcare components that made the total: inpatient stays, emergency room visits, outpatient visits, prescription drugs, and other services, which included dental care, home health care, vision aids, and other miscellaneous items. All expenditures were inflated to 2014 U.S. dollars using the gross domestic product deflator.[16]

The analysis controlled for covariates: age group, sex, race/ethnicity, marital status, education level, Census region of residence, type of health insurance coverage, current smoking status, and self-rated health status. Survey years were also included to account for the influence of aggregate time effects. The variance inflation factors for covariates were small, indicating no multi-collinearity among these covariates.

Statistical Analysis

Separate analyses were conducted for patients with AMI and those with AIS, adjusting for all covariates. For each of the two conditions, the medical expenditures associated with diabetes for each of the healthcare components were estimated. For outpatient visits and prescription drugs, general linear models (GLMs)[17] with a log link and gamma distribution to estimate per capita annual expenditure were used, conditional on covariates. The gamma-variance function was selected by performing a modified Park test.[17] A large proportion of patients (> 29%) did not incur any medical expenses for inpatient stays, emergency room visits, and other services. Therefore, two-part models were used to estimate the expenditures on these components, as such models have been shown to be suitable for continuous non-negative outcomes with a large proportion of zero values and a fat-tailed distribution.[18] In

the first part of the two-part model, the likelihood of an individual incurring any medical expenditure was estimated using a logit model. In the second part, GLMs with a log link and gamma distribution were used to estimate the medical expenditures for people with positive medical expenses.[17] Mathematical equations of the estimation models and main Stata codes are provided in the Appendix (available online). Parameters estimated from the GLMs and the two-part models were then used to predict adjusted expenditures for each individual by assuming (1) each individual had diabetes and (2) each individual did not have diabetes. The excess expenditure was calculated as the difference between (1) and (2). It represents the difference between the estimated expenditures conditional on having both diabetes and AMI (or AIS) and the estimated expenditure conditional on having AMI (or AIS) but not diabetes. The component expenditures were then summed for each individual to obtain total individual-level expenditure. The reported per capita adjusted expenditures as well as the 95% CI were calculated among the study sample.

A sensitivity analysis was conducted by controlling for hypertension and hyperlipidemia in addition to all the aforementioned covariates. Hypertension and hyperlipidemia are common for patients with diabetes, AMI, and AIS. They are also risk factors for both AMI and AIS. Controlling for these two conditions would provide excess medical expenditures associated with diabetes without the impacts of the two conditions.

To explore the relative contribution of increased utilization (volume) versus per unit expenditure (price) on excess expenditure, the unadjusted mean utilization (in terms of the number of health services) and per unit expenditures were calculated for each utilization for those with and without diabetes.

For all analyses, sample weights and variance stratum were adjusted for the pooled years of surveys to ensure a nationally representative study sample.[19] All analyses were conducted using Stata, version 14, with a p-value <0.05 considered statistically significant. The analysis was conducted in 2017.

RESULTS

AMI and AIS patients with diabetes differed from those without diabetes (Table 1). Among AMI patients, those with diabetes were significantly older, more likely to be female, and less likely to be non-Hispanic white. AIS patients showed similar patterns, except that the differences in some characteristics between people with and without diabetes were not statistically significant. Unadjusted sample means of medical expenditures by diabetes status among AMI patients and AIS patients are reported in Appendix Table 1 (available online).

The estimated annual excess medical expenditures associated with diabetes among AMI and AIS patients in total and by healthcare components, controlling for covariates, are presented in Table 2. For AMI patients, having diabetes was associated with an additional $5,117 (95% CI=$4,989, $5,243) in total medical expenditures. The majority of these excess medical expenditures were spent on prescription drugs ($2,035), inpatient stays ($1,552), and outpatient visits ($1,295). The excess expenditures associated with diabetes for AIS patients were slightly higher: $5,734 (95% CI=$5,579, $5,887) in total, including $2,430

for prescription drugs, $1,654 for outpatient visits, and $1,314 for inpatient stays. Adding hypertension and hyperlipidemia to the model produced slightly lower excess expenditures for AMI patients, but similar estimates for AIS patients (Appendix Table 2, available online).

Excess medical expenditures associated with diabetes were driven more by the increased volume of medical services than by the increased per-unit expenditure (Table 3). AMI patients with diabetes, on average, had 55% more prescription drug refills; 43% more inpatient stays (with 39% more inpatient nights); and 24% more outpatient visits than those without diabetes. Although per unit expenditures were also generally higher for those with diabetes than those without, the relative magnitude of the differences were smaller. Similar patterns were observed for AIS patients.

DISCUSSION

To the authors' knowledge, this study is the first to assess excess medical expenditures associated with diabetes for AMI and AIS patients in the U.S. using a nationally representative population. The study found that among AMI patients, those with diabetes spent $5,117 more per year on medical expenditures (about 1.3 times as much) than those without diabetes. Among patients with AIS, additional per capita expenditures for those with diabetes were $5,734 (1.3 times as much) more than those without. Higher spending on prescription drugs, inpatient stays, and outpatient visits contributed most to these excess expenditures.

These findings are consistent with existing literature on overall medical expenditures among people with diabetes. A multisource American Diabetes Association study estimated that people with diabetes spent $7,900 more (2.3 times as much) on health care than those without diabetes in 2012.[9] Another study by Zhuo et al.,[8] which used 2010–2011 MEPS-HC data, reported that estimated total annual excess expenditure associated with diabetes among the general population was $5,378, or 1.7 times as much as expenditures of those without diabetes. These estimates of total excess expenditures were similar to the current study estimates for AMI ($5,117) and AIS patients ($5,734). The lower relative differences found in the current study (1.3 times) is due to the higher baseline expenditures of the study population, which consisted of people with CVD rather than the general U.S. population as studied by Zhuo et al.[8]

Applying population weights to the 2014 MEPS-HC data, 5.0 million non-institutionalized U.S. adults with AMI and 3.7 million with AIS incurred medical expenses. Of these, approximately 2.1 million AMI patients and 1.5 million AIS patients also had diabetes. Applying the excess expenditures associated with diabetes estimated from the current study, it is estimated that diabetes added approximately $10.7 billion in expenses to the national healthcare system among non-institutionalized patients with AMI, and approximately $8.6 billion among those with AIS in 2014.

Estimates from this study suggest that higher expenditures on prescription drugs were the most costly contributor to total excess medical expenditures associated with diabetes.

For people with AMI, $2,035, or 40% of the $5,117 total, was because of prescription drugs. Similarly, for those with AIS, $2,430, or 42% of the $5,734 total, was because of additional spending on prescription drugs. Maintaining optimal glucose levels through pharmaceutical treatment is essential to diabetes care, especially for those with both diabetes and prior CVD.[20] From 1987 to 2011, expenditures on drugs related to glucose control grew faster than expenditures on drugs among the general population.[8] In 2010, spending on antidiabetic drugs, including oral agents and insulin, reached $16 million (in 2014 U.S. dollars) for people aged < 40 years.[21] The current study found that AMI and AIS patients with diabetes had 55%–64% more prescription drug refills than those without diabetes. This excess could be due to intensive pharmaceutical treatment of diabetes as well as treatment for common complications, such as hypertension and hyperlipidemia, among people with diabetes and AMI or AIS.

Higher medical expenditures on both inpatient and outpatient cares also contributed substantially to total excess medical expenditures associated with diabetes among AMI and AIS patients. To a large degree, higher expenditures were driven by a higher volume of utilization. AMI and AIS patients with diabetes had 24%–43% more inpatient stays and outpatient visits than those without diabetes. Such higher utilization could be due to more severe AMI and AIS in patients with diabetes. Previous studies found a higher recurrence rate of AMI and AIS among patients with diabetes than among those without,[5,22] and AMI and AIS are also more difficult to manage when these conditions coexist with diabetes.[23,24] The higher medical expenditures associated with per inpatient stay, per inpatient night, and per outpatient visit could be due to the additional complexity of managing both CVD and diabetes.

Limitations

This study has several limitations. First, the MEPS-HC does not survey individuals in institutional care, such as nursing homes. Excess medical expenditures associated with diabetes are likely to be higher in those populations. Second, these estimates include only patients with non-fatal conditions, because MEPS-HC does not collect information among patients with fatal myocardial infarction and stroke. The excess medical expenditures associated with diabetes among patients with fatal AIM or AIS could be higher or lower, depending on the treatment given and timing of death. Third, MEPS-HC survey data are subject to measurement error. Conditions, treatments, and diagnoses were self-reported and may include reporting error. However, MEPS-HC has been shown to provide accurate reports on inpatient stays, which account for the majority of total health care expenditures.[25] Fourth, it was not possible to differentiate type 1 and type 2 diabetes in the study sample, and thus the reported estimates represent a weighted average. Fifth, the estimated excess expenditures associated with diabetes do not reflect a causal effect of diabetes on the medical expenditures of patients with AMI and AIS.

CONCLUSIONS

In summary, diabetes is associated with large excess medical expenditures among AMI and AIS patients, resulting in approximately $19 billion of annual excess medical expenditures

nationally. These excess expenditures are mainly because of prescription drug uses, inpatient stays, and outpatient visits. As 95% of diabetes cases in the U.S. are type 2,[3] which is preventable, these findings highlight the importance of type 2 diabetes prevention efforts. In addition, high-quality care for people with diabetes, including better control of glucose, blood pressure, and cholesterol levels, may alleviate some AMI and AIS, which in turn would lower medical costs. A large proportion of excess medical expenditures from prescription drugs suggests a need to use diabetes drugs that are both effective and cost effective. Further studies are needed to identify better strategies for reducing expenditures without compromising outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

Sample Characteristics by Diabetes Status Among Adults With AMI and AIS[a]

Characteristics	AMI patients			AIS patients		
	Without DM (*n*=1,997)	With DM (*n*=1,310)	*p*-value[b]	Without DM (*n*=1,521)	With DM (*n*=939)	*p*-value
Age (years), %			**<0.05**			**<0.05**
18–44	5.2	2.4		6.4	2.3	
45–64	33.5	35.2		29.7	30.7	
≥65	61.3	62.3		63.9	67.0	
Female, %	34.7	36.2	**<0.05**	56.0	51.5	0.18
Race/ethnicity, %			**<0.05**			**<0.05**
Non-Hispanic white	84.0	74.1		78.7	68.6	
Non-Hispanic black	7.4	10.5		12.0	16.8	
Hispanics	5.8	9.4		5.5	9.7	
Other races	2.8	6.1		3.7	4.8	
Married, %	56.0	62.9	**<0.05**	50.5	49.1	0.77
Education, %			**<0.05**			**<0.05**
Less than high school	20.1	25.7		19.5	26.1	
High school graduate	46.7	44.9		46.2	45.5	
Some college or higher	33.1	29.3		34.3	28.5	
Census region, %			**<0.05**			0.19
Northeast	17.9	19.7		17.7	19.0	
Midwest	25.5	25.4		23.7	23.1	
South	38.1	40.8		38.4	39.9	
West	18.5	14.2		20.1	18.0	
Health insurance coverage, %			**<0.05**			**<0.05**
Any private	56.9	53.9		52.9	43.4	
Public only	39.3	41.9		43.6	54.1	
Uninsured	3.9	4.2		3.5	2.5	
Current smoker, %	20.3	17.4	**<0.05**	16.1	15.6	0.19
Self-rated medical health, %			**<0.05**			**<0.05**
Good	65.8	45.2		58.6	44.5	

Characteristics	AMI patients			AIS patients		
	Without DM (*n*=1,997)	With DM (*n*=1,310)	*p*-value[b]	Without DM (*n*=1,521)	With DM (*n*=939)	*p*-value
Fair	22.2	33.5		25.9	32.6	
Poor	12.0	21.3		15.5	22.9	
Mean total medical expenditure (in 2014 $)	15,087	22,609	**<0.05**	16,185	22,599	**<0.05**

Note: Boldface indicates statistical significance ($p<0.05$).

[a]Data were from the 2008–2014 Medical Expenditure and Panel Survey. Adults refer to individuals aged ≥18 years. All statistics were appropriately weighted to ensure national representativeness. AMI was identified by ICD-9-CM code 410. AIS was identified by ICD-9-CM codes 433, 434, and 436. DM was identified by ICD-9-CM code 250.

[b]*t*-test was used to test the mean difference between individuals with and without DM; χ^2 test was used to test the distribution difference of categories between individuals with and without DM.

AIS, acute ischemic stroke; AMI, acute myocardial infarction; DM, diabetes mellitus.

Table 2.

Estimated[a] Medical Expenditures (2014 $) Associated With Diabetes Among Adults With AMI and AIS[b]

	AMI patients			AIS patients		
Components	**Without DM**	**With DM**	**Excess Expenditure[c]**	**Without DM**	**With DM**	**Excess expenditure**
Inpatient stays, $	7,812 (7,470, 8,154)[d]	9,364 (8,967, 9,761)	1,552 (1,496, 1,607)	6,915 (6,563, 7,267)	8,229 (7,817, 8,641)	1,314 (1,254, 1,374)
Emergency room visits, $	718 (681, 756)	809 (767, 851)	91 (86, 95)	677 (641, 714)	715 (677, 753)	38 (35, 39)
Outpatient visits, $	3,762 (3,645, 3,880)	5,057 (4,899, 5,215)	1,295 (1,254, 1,335)	3,564 (3,404, 3,725)	5,218 (4,983, 5,452)	1,654 (1,579, 1,728)
Prescription drugs, $	3,407 (3,319, 3,494)	5,442 (5,303, 5,582)	2,035 (1,983, 2,088)	3,250 (3,172, 3,327)	5,680 (5,544, 5,815)	2,430 (2,372, 2,488)
Other services, $	1,734 (1,643, 1,826)	1,878 (1,779, 1,976)	144 (136, 150)	3,143 (2,933, 3,352)	3,441 (3,211, 3,671)	298 (278, 320)
Total, $	17,433 (16,871, 17,997)	22,550 (21,863, 23,237)	5,117 (4,989, 5,243)	17,549 (16,921, 18,177)	23,283 (22,508, 24,056)	5,734 (5,579, 5,887)

[a]Adjusted for age group, sex, race/ethnicity, marital status, education level, geographic Census region of residence, type of health insurance coverage, current smoking status, self-rated health status, and survey year. Medical Expenditures were reported as per-capita annual expenditure.

[b]Data were from the 2008–2014 Medical Expenditure and Panel Survey. Adults refer to individuals aged ≥18 years. All statistics were appropriately weighted to ensure national representativeness. AMI was identified by ICD-9-CM code 410. AIS was identified by ICD-9-CM codes 433, 434, and 436. DM was identified by ICD-9-CM code 250.

[c]Excess expenditure was calculated by the estimated expenditures for individuals with DM minus the estimated expenditures for individuals without DM.

[d]Values in parentheses are the 95% CIs.

AIS, acute ischemic stroke; AMI, acute myocardial infarction; DM, diabetes mellitus.

Table 3.

Mean Utilization[a] and Per-Unit Expenditures of Medical Services by Diabetes of Adults With AMI and AIS[b]

Components	AMI patients					AIS patients				
	Without DM	With DM	AD[c]	RD, %	*p*-value[d]	Without DM	With DM	AD	RD, %	*p*-value
Inpatient stays, *n*	0.42 (0.38, 0.47)[e]	0.60 (0.53, 0.66)	0.17	43	**<0.05**	0.45 (0.4, 0.5)	0.58 (0.49, 0.67)	0.13	29	**<0.05**
Inpatient nights, *n*	2.23 (1.84, 2.63)	3.11 (2.67, 3.54)	0.88	39	**<0.05**	3.08 (2.37, 3.79)	4.00 (3.23, 4.78)	0.92	30	**<0.05**
Emergency room visits, *n*	0.50 (0.45, 0.55)	0.62 (0.55, 0.68)	0.12	24	**<0.05**	0.60 (0.53, 0.68)	0.68 (0.59, 0.77)	0.08	13	**<0.05**
Outpatient visits, *n*	13.34 (12.28, 14.39)	16.52 (14.98, 18.05)	3.18	24	**<0.05**	13.66 (12.51, 14.81)	17.05 (15.33, 18.78)	3.39	25	**<0.05**
Prescription drugs, *n*	40.52 (38.06, 42.98)	62.63 (58.6, 66.65)	22.10	55	**<0.05**	38.17 (35.87, 40.47)	62.66 (58.32, 66.99)	24.49	64	**<0.05**
Inpatient stays, $	4,311 (3,755, 4,867)	5,523 (4,822, 6,223)	1,212	28	**<0.05**	4,195 (3,183, 5,206)	4,737 (3,912, 5,562)	542	13	0.24
Inpatient nights, $	1,485 (1,258, 1,712)	1,784 (1,446, 2,122)	299	20	**<0.05**	888 (754, 1,020)	1,130 (880, 1,379)	242	27	**<0.05**
Emergency room visits, $	420 (319, 521)	579 (192, 966)	159	38	0.28	437 (299, 575)	402 (307, 496)	−35	−8	0.56
Outpatient visits, $	314 (223, 405)	296 (261, 331)	−18	−6	0.55	249 (225, 273)	283 (242, 325)	34	14	**<0.05**
Prescription drugs, $	78 (73, 83)	88 (80, 96)	10	13	**<0.05**	84 (75, 93)	91 (83, 100)	7	8	0.07

Note: Boldface indicates statistical significance ($p<0.05$).

[a] Mean utilization was measured as per-capita annual use of medical services, which is in count numbers. Per-unit expenditure was measured as the average expenditure for each usage of corresponding medical services, which is in 2014 U.S. dollars.

[b] Data were from the 2008–2014 Medical Expenditure and Panel Survey. Adults refer to individuals aged ≥18 years. All statistics were appropriately weighted to ensure national representativeness. AMI was identified by ICD-9-CM code 410. AIS was identified by ICD-9-CM codes 433, 434, and 436. DM was identified by ICD-9-CM code 250.

[c] AD represents absolute difference. RD is relative difference. Relative difference is the percentage difference in the expenditures for persons with diabetes versus persons without diabetes.

[d] Independent sample *t*-test was used to test whether the means of individuals with and without diabetes were significantly different.

[e] Values in parentheses are the 95% CIs.

AIS, acute ischemic stroke; AMI, acute myocardial infarction; DM, diabetes mellitus.