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Medical care expenditures associated with chronic kidney disease in adults with diabetes: United States 2011

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Abstract

Objective: Approximately 1 in 3 adults with diabetes have CKD. However, there are no recent national estimates of the association of CKD with medical care expenditures in individuals with diabetes. Our aim is to assess the association of CKD with total medical expenditures in US adults with diabetes using a national sample and novel cost estimation methodology.

Research design and methods: Data on 2,053 adults with diabetes in the 2011 Medical Expenditure Panel Survey (MEPS) was analyzed. Individuals with CKD were identified based on self-report. Adjusted mean health services expenditures per person in 2011 were estimated using a two-part model after adjusting for demographic and clinical covariates.

Results: Of the 2,053 individuals with diabetes, approximately 9.7% had self-reported CKD. Unadjusted mean expenditures for individuals with CKD were $20,726 relative to $9,689.49 for no CKD. Adjusted mean expenditures from the 2-part model for individuals with CKD were $8473 higher relative to individuals without CKD. Additional significant covariates were Hispanic/other race, uninsured, urban dwellers, CVD, stroke, high cholesterol, arthritis, and asthma. The estimated unadjusted total expenditures for individuals with CKD were estimated to be in excess of $43 billion in 2011.

Conclusions: We showed that CKD is a significant contributor to the financial burden among individuals with diabetes, and that minorities and the uninsured with CKD may experience barriers

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Author contributions:

LEE obtained funding for the study. LEE designed the study, acquired, analyzed and interpreted the data. LEE, MNO, CPL, and CEB developed the analysis, contributed to interpretation and critically revised the manuscript for important intellectual content. All authors approved the final manuscript.

Conflicts of interest statement

The authors report no potential conflicts of interest relevant to this article.

Guarantors:

LEE and MNO are the guarantors of the study and take full responsibility for the work as a whole, including the study design, access to data, and the decision to submit and publish the manuscript.

in access to care. Our study also provides a baseline national estimate of CKD cost in Diabetes by which future studies can be used for comparison.

Keywords

Diabetes; Chronic kidney disease; Cost; MEPS

1. Global burden of chronic kidney disease in type 2 diabetes

The International Diabetes Federation (IDF) estimates the global prevalence of diabetes in 2013 to be 381.8 million adults and projects that this will rise to 591.9 million in 2035 [1]. In the US, 21 million people have been diagnosed with type 2 diabetes and approximately 1 in 3 adults with diabetes have Chronic Kidney Disease (CKD) (defined as glomerular filtration rate <60 mL/min/1.73 m^3 for >3 months) [2,3]. Over the past two decades, diabetes related CKD has been on the rise in the US [4]. According to the Center for Disease Control (CDC), in 2011 over 49,000 people of all ages started treatment for diabetes related renal failure and a total of 228,924 people with diabetes related renal failure were living on chronic dialysis or with kidney transplants [2]. Lozano et al revealed that diabetes and CKD were second and third respectively to HIV/AIDs in the 2013 rank list of diseases with the largest increase in the global mortality rate from 1990 to 2010 [5].

The total estimated direct medical cost of diabetes in the US in 2012 was $176 billion [2], which is 2.3 times higher compared to people without diabetes. The long-term complications of diabetes account for a significant proportion of the costs of the treatment of diabetes [6] and CKD is one of the most expensive complications of diabetes [7]. CKD is associated with approximately 65% to 771% increase in cost depending on the stage of renal disease [6]. The USRDS reports Medicare patients with CKD and diabetes incurred mean annual per capita costs of $18611 and total expenditures of $24.6 billion in 2011 [8]. The projected increasing prevalence of diabetes, diabetes related CKD and the associated health care costs, represents an enormous public and economic burden [7]. Few studies have examined the economic impact and cost of diabetes related CKD in the US [6–9]. To the best of our knowledge there are no recent studies on national estimates for the cost of CKD in adults with diabetes in the US population.

The aim of this study is to assess the cost of CKD in adults with diabetes in the US population by using a novel cost estimation methodology and a nationally representative longitudinal survey that collects data on demographics, socioeconomic status, health status, use of medical care services, health insurance coverage and comorbidities.

2. Research design and methods

2.1. Study population

We analyzed data from 2,053 individuals >17 years old with self-reported diabetes in the Medical Expenditure Panel Survey (MEPS) consolidated file for 2011. The MEPS is cosponsored by the Agency for Healthcare Research and Quality and the National Center for Health Statistics [10]. The MEPS sample is drawn from reporting units in the previous year's National Health Interview Survey, a nationally representative sample (with oversampling for Blacks and Hispanics) of the US civilian non-institutionalized population. The consolidated file contains detailed information on demographic characteristics, self-reported health conditions, health status, medical services utilization, charges and sources of payment, access to care, satisfaction with care, health insurance coverage, income and employment for each person in the household.

2.2. Definition of outcome

The primary outcome variable was annual total direct medical expenditures, defined as patient out-of-pocket as well as all third party (Medicare, Medicaid, private insurance, other) payments for medical services - office and hospital-based care, home health care, prescribed medicines, dental services, and other medical equipment and services reported during the calendar year. Payments for over-the-counter drugs and phone services as well as indirect Medicare/Medicaid payments for disproportionate share and direct medical education are not included. Any provider charges associated with uncollected liability, bad debt, and charitable care (unless provided by a public clinic or hospital) are not counted as expenditures [10].

2.3. Primary independent variable

Respondents were identified as having diabetes if they responded yes to the question: "Have you ever been told by a doctor or health professional that you have diabetes?" Respondents were identified as having CKD (chronic kidney disease) if they responded yes to the question "Has diabetes caused kidney problems?"

2.4. Covariates

Additional covariates included in the expenditure model were race/ethnicity, age, gender, marital status, education, insurance, metropolitan statistical area (MSA), region, poverty/income ratio, and comorbidities - depression, hypertension, cardiovascular disease (CVD), stroke, emphysema, high cholesterol, joint pain, arthritis, and asthma. These variables were included based on clinical relevance and findings from prior research. Demographic variables were measured in categories: race/ethnicity in 3 categories of non-Hispanic White (NHW), non-Hispanic Black (NHB), and Hispanic/other; age in 3 categories of 18–44, 45–64, and 65 and older; marital status in 3 categories of married, widow/divorced/single (not married), and never married; education in 3 categories as less than high school, high school, and college or more; insurance in 3 categories of private, public, and uninsured; region in 4 categories of Northeast, Midwest, South and West; Poverty/income ratio in 3 categories of poor and near poor (<125% of 2011 federal poverty level), low income (≥125% and <200% federal poverty level), middle income (≥200% and <400% federal poverty level) and high income (greater than equal to 400% poverty level). Gender was dichotomized as male vs female and MSA as MSA (urban) vs. non-MSA (rural). Comorbidities were measured as binary variables based on self-report for the following conditions: depression, hypertension, cerebrovascular disorder, stroke, emphysema, high cholesterol, joint pain, arthritis and asthma.

2.5. Statistical analyses

We performed three sets of analyses. First, we compared demographic characteristics of the sample with diabetes by CKD status using chi-square statistics. Second, we estimated unadjusted mean direct medical expenditures for individuals with diabetes by CKD status using *t*-test. Third, we used the two-part model to estimate the adjusted direct medical expenditures for individuals with diabetes by CKD status after controlling for demographic and comorbidity covariates. In order to obtain adjusted estimates of the association of CKD with expenditures among individuals with diabetes, we estimated a two part general linear model (GLM) allowing for mixed discrete-continuous variables [11]. In the two-part model, a binary choice model is estimated for the probability of observing a zero versus positive value for any health expenditure. Conditional on having any health expenditure, a GLM with gamma distribution and a log link was estimated for the expenditures >0 [12]. The gamma model is used for data situations in which the responses take only values ≥0 [13]. Expenditure data are typically right-skewed because a relatively small proportion of patents incur extremely high expenditures and the GLM with log link and gamma variance function takes this problem into account [13]. Since the dependent variables in our study were characterized by a significant number of zero observations, using the two-part GLM improves the precision of our estimates [14]. This allows the users to leverage the capabilities of margins to calculate marginal effects and their standard errors from both the first and second parts of the final model [12]. The use of GLM in the second part has an advantage over log OLS since it relaxes the normality and homoscedasticity assumptions and avoids problems associated with retransforming to the raw scale [12].

In order to generalize our study findings to the U.S population, the complex sampling design of MEPS dataset was taken into account by using sampling weight, variance estimation stratum and primary sampling unit (clustering). The weighted two-part model was used to estimate direct health expenditures associated with CKD among individuals with diabetes, adjusting for demographic factors and comorbidities and to estimate the total burden of CKD among individuals with diabetes in the US population. *F*-test for both of the two-part regression models were found to be significant, which indicated the overall significance of the regression model.

To determine the family distribution for the GLM, we used the modified Park test [11,12] taking into account the complex survey design. The Park test used both the full and the positive portion of the distribution of direct medical care expenditures [12]. The results of the modified Park test confirmed using the gamma distribution with a log link was the best-fitting GLM for consistent estimation of coefficients and marginal effects of medical expenditures. Total direct medical expenditure burden of CKD among the U.S. population with diabetes was calculated by multiplying the unadjusted mean direct medical expenditure per individual by the population estimated to have diabetes and CKD. All analyses were conducted using STATA 13, and $p < 0.05$ was considered statistically significant.

3. Results

Of the 2,053 individuals with diabetes, 9.7% were found to have CKD. Statistical differences in demographics and comorbidities of individuals with diabetes by CKD status were found for poverty/income ratio, depression, hypertension, CVD, high cholesterol, joint pain, arthritis and asthma. Those with diabetes and CKD were more likely to be poor/near poor (<125% Federal Poverty Level) or have middle income (≥200% & <400% Federal Poverty Level). Individuals with diabetes and CKD were more likely to have depression, hypertension, CVD, high cholesterol, joint pain, arthritis and asthma (see Table 1).

3.1. Unadjusted CKD direct medical care expenditures in diabetes

As shown in Table 2, individuals with diabetes and CKD were estimated to have unadjusted mean direct expenditures in 2011 of $20,726 (95% CI $16,322–$25,130) relative to diabetes and no CKD of $9,689 (95% CI $8871–$10,507). Based on the unadjusted mean direct expenditures per person with diabetes and CKD and estimated number of individuals with diabetes and CKD in the US population (2,092,489), we estimated the financial burden of CKD among the US population with diabetes to be $43.3 billion.

3.2. Adjusted CKD direct medical care expenditures in diabetes

After adjusting for demographic and comorbidity covariates, CKD was associated with $8,473 (95% CI $4957–$11,989) higher direct medical expenditures relative to no CKD among individuals with diabetes (see Table 3). Additional significant covariates were Hispanic/other race, uninsured, urban dwellers, CVD, stroke, high cholesterol, arthritis, and asthma. NHB race, age, gender, martial status, education, public insurance, region, poverty/income ratio, hypertension, emphysema, and joint pain were not significant. The adjusted mean direct expenditures and financial burden of CKD based on the estimated number of individuals with diabetes and CKD in the US population (2,092,489) was approximately $17 billion.

4. Discussion

Our analyses of adults with diabetes showed that individuals with CKD had substantially higher mean direct expenditures ($11,037) compared to individuals with diabetes and no concomitant CKD. Urban dwellers had significantly higher direct medical expenditures while the uninsured and minorities especially Hispanics had significantly lower expenditures. The higher expenditures among urban dwellers could be from greater access to care, while lower expenditures in the uninsured and minorities may be related to lower access to care.

4.1. Comparison with existing cost estimates

The prevalence of CKD in this population is lower (9.7%) than other reports of national estimates from the National Health and Nutrition Examination Survey (NHANES) data with 14% prevalence [15] and the USRDS with 14% prevalence. However, differences in prevalence are likely related to the different data collection methods across national data sources. For example, the NHANES database has laboratory data with estimated glomerular filtration rate (eGFR) and therefore able to detect undiagnosed CKD, the USRDS includes all patients with severe disease (End Stage Renal Disease) regardless of age, while MEPS applies ICD-9 codes from self-reported presence of kidney disease. Previous studies have shown higher cost associated with diabetes related CKD similar to our study [6,7,9,16]. The adjusted mean direct expenditure estimate of $17 billion in our study for the US population was lower than USRDS annual report of $25 billion. However, USRDS population is a sicker population, which largely explains this difference. On the other hand, our adjusted total direct expenditure estimate was marginally higher than Laliberte and colleagues who estimated direct costs of $7,190 [9] associated with CKD in a managed care population with diabetes and comorbid hypertension. A recent study by Vupputuri et al on the cost of progression of CKD in individuals with T2DM showed an increase in mean healthcare cost ($4,569–$33162 depending on disease severity) but we are unable to accurately compare our estimates with theirs since their estimates were based on the CKD severity [7].

5. Conclusions

The findings from this study are nationally representative and present the most recent assessment of the cost attributable to CKD in individuals with diabetes. A unique attribute and strength of our study is the use of a novel two-part methodology for cost estimation, which took into account zero expenditures and the skewed distribution of expenditure data. For example, 2% of the sample had zero expenditures. In addition, the overall total mean direct expenditures for the sample was $10,765 (95% CI $9,923–$11,606), whereas the total mean expenditures for the upper 3% (right tail) of the expenditure distribution for the same sample was $46,701 (95% CI $22,773–$253,301). Hence, this gives a more accurate cost estimate in patients with diabetes and comorbid CKD. Despite these strengths, the limitations of our study include absence of laboratory data (eGFR and albumin creatinine ratios) for identifying and staging CKD patients, hence inability to characterize CKD severity. Second, CKD was based on self-reported data among those with diabetes, which likely underestimates the prevalence and expenditure data in these individuals with CKD. A study by Machlin et al revealed that individuals with salient diseases requiring specific, ongoing treatment tend to be accurate in reporting their conditions [17]. However, specific management of CKD is generally embedded in the treatment of another chronic condition, most often hypertension and/or diabetes. So it is more likely that patients are less aware of their diabetes-related CKD status. This amplifies the importance of further research in this area. Third, our study is also limited by its cross-sectional nature. Additional research needs to examine the longitudinal impact of CKD on cost outcomes in people with diabetes. Fourth, our sample includes individuals with type 1 (which is a non-preventable disease) as well as type 2 diabetes and as such may overestimate potential savings.

Regardless, our findings emphasize the need for aggressive measures and strategies for the prevention, early recognition, treatment of diabetes and diabetes related CKD. According to the CDC, 28% of people with diabetes are undiagnosed [2]. Additionally, Stark et al showed that during the period of 2007 to 2010 only 53% of patients with diabetes reached target A1c goals [18]. Provision of optimal care to individuals with diabetes is critical, which by and large culminates in control of disease and subsequently retards the progression of diabetes-related complications like CKD. In addition, new policies addressing this grassroots problem of undiagnosed diabetes with its resulting complications are a good starting point to halt this epidemic. With the knowledge that patients achieve good diabetes control by virtue of their own actions and behaviors, programs geared towards promoting provider-initiated patient education and improved communication between health care providers and patients is of the essence and imperative to reduce complications of diabetes.

In conclusion, our study showed comorbid CKD is associated with higher mean direct expenditures in individuals with diabetes; urban residence is independently associated with higher expenditure whereas Hispanics and uninsured populations are not. The growing economic and public health burden of diabetes and its most expensive complication – CKD – calls for an interdisciplinary approach and heightened awareness amongst providers, to identify and strategize to meet the needs of high-risk diabetes patients in order to prevent and delay disease progression. All in all, our study provides a baseline national cost estimate of CKD in diabetes by which future studies can be used for comparison. Additionally, this study provides estimates for potential savings from future interventions geared towards reduction of CKD development in diabetes.

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Table 1 –

Sample demographics among people with diabetes by CKD status.

	All (%)	CKD (%)	NO CKD (%)	*p-Value
Race				0.639
NH Whites	61.76	60.66	61.88	
NH Blacks	16.33	14.93	16.48	
Hispanics/other	21.91	24.41	21.64	
Age (years)				0.815
18–44	13.79	15.27	13.63	
45–64	47.39	45.24	47.62	
65+	38.81	39.48	38.74	
Sex				0.080
Men	49.91	42.67	50.69	
Women	50.09	57.33	49.31	
Marital Status				0.141
Married	56.06	51.30	56.57	
Widow/divorce/single	32.06	38.81	31.33	
Not married	11.88	9.89	12.10	
Education				0.401
Less than high school	21.20	25.19	20.77	
High school	33.33	34.37	33.22	
College or more	45.47	40.44	46.01	
Insurance				0.158
Private	60.58	53.51	61.34	
Public	31.01	37.53	30.32	
Uninsured	8.41	8.96	8.35	
MSA				0.066
Rural	18.73	24.24	18.14	
Urban	81.27	75.76	81.86	
Region 2011				0.204
Northeast	15.84	15.85	15.83	
Midwest	23.27	15.54	24.10	
South	41.94	47.24	41.38	
West	18.95	21.37	18.69	
Poverty income ratio				0.018
Poor/NEA	20.73	28.13	19.94	
Low income	14.90	13.42	15.06	
Middle income	31.73	35.37	31.34	
High income	32.64	23.08	33.67	
Depression				<0.001
Not depressed	84.61	73.92	85.77	
Depressed	15.39	26.08	14.23	

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	All (%)	CKD (%)	NO CKD (%)	*p-Value
Hypertension				0.009
No hypertension	23.59	14.17	24.61	
Hypertension	76.41	85.83	75.39	
CVD				0.001
No CVD	68.63	55.97	69.99	
CVD	31.37	44.03	30.01	
Stroke				0.059
No stroke	89.33	84.83	89.81	
Stroke	10.67	15.17	10.19	
Emphysema				0.288
No emphysema	96.07	94.33	96.26	
Emphysema	3.93	5.67	3.74	
High cholesterol				0.002
Absent	28.51	17.70	29.68	
Present	71.49	82.30	70.32	
Joint pain	(%)	(%)	CKD (%)	0.001
No joint pain	46.37	33.39	47.77	
Joint pain	53.63	66.61	52.23	
Arthritis				0.003
No arthritis	50.51	37.88	51.86	
Arthritis	49.49	62.12	48.14	
Asthma				0.007
No asthma	86.84	79.48	87.63	
Asthma	13.16	20.52	12.37	

*Level of significance $p < 0.05$ for each category.

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Table 2 –

Means of total expenditure by CKD status among adults with diabetes.

	Mean ($)	95% CI	*p-Value
			<0.00l
NoCKD	$9,689	$8,871–$10,507	
CKD	$20,726	$16,322–$25,130	

*Level of significance $p < 0.05$ for each category.

Table 3 –

Two-part regression model: mean total direct expenditure by CKD status accounting for probability of having expenditure and relevant covariates.

	Adjusted mean	95% CI	*p-Value
No DMCKD (ref)	-	-	-
DMCKD	$8473	$4957–$ll,989	<0.001
Race			
NH White (ref)	-	-	-
NH Black	−$1479	−$3503–$544	0.152
Hispanic/other	−$3228	−$5130–$l,325	0.001
Age (years)			
18–44 (ref)	-	-	-
45–64	$659	−$1973–$3,292	0.624
65+	−$731	−$3441–$1977	0.596
Gender			
Men (ref)	-	-	-
Women	$1359	−$0–$2718	0.050
Marital status			
Married (ref)	-	-	-
W/D/S	$69	−$1756–$1895	0.941
Not married	$2736	−$608–$6082	0.109
Education			
Less than high school (ref)	-	-	-
High school	$420	−$1641–$2481	0.690
College or more	$992	−$1016–$3000	0.333
Insurance			
Private (ref)	-	–	-
Public	−$1363	−$3382–$655	0.186
Uninsured	−$6306	−$8494–$4118	<0.001
MSA			
Rural (ref)	-	-	-
Urban	$2392	$661–$4122	0.007
Region			
Northeast (ref)	-	-	-
Midwest	$2199	−$163–$4561	0.068
South	$763	−$1248–$2775	0.457
West	$295	−$1929–$2520	0.795
Poverty income ratio			
Poor/near poor (ref)	-	-	-
Low income	−$2084	−$4448–$279	0.084
Middle income	−$1713	−$4121–$694	0.163
High income	−$900	−$4140–$2340	0.586

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	Adjusted mean	95% CI	*p-Value
Hypertension			
Yes	$1486	−$259–$3232	0.095
CVD			
Yes	$4339	$2714–$5965	<0.001
Stroke			
Yes	$5986	$3450–$8523	<0.001
Emphysema			
Yes	$2732	−$1262–$6726	0.180
High cholesterol			
Yes	$1967	$263–$3671	0.024
Joint pain			
Yes	$794	−$913–$2502	0.362
Arthritis			
Yes	$2657	$766–$4549	0.006
Asthma			
Yes	$2954	$349–$5560	0.026

*Level of significance $p < 0.05$ for each category.