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Research Paper

Economic burden of diabetes among medicare beneficiaries with cancer

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Abstract

Objectives Older adults are commonly affected by cancer and diabetes, and an investigation of the economic burden faced by these older adults remains a research gap. Therefore, the objective was to assess the economic burden of diabetes among Medicare beneficiaries with cancer by analyzing annual costs from administrative claims data.

Methods We conducted a retrospective, serial cross-sectional study using the Medicare Current Beneficiary Survey (MCBS) from 2006 to 2012. Eligible beneficiaries must be currently or previously diagnosed with cancer (of any type), ≥65 years of age, non-institutionalized and continuously enrolled annually in Medicare Parts A, B and D. Diagnoses of cancer and diabetes were determined through self-report or claims. The primary outcome was the total economic burden of diabetes per capita annually, operationalized as the difference in total direct costs between cancer patients with and without diabetes. Simple linear regression was used to analyze trends of costs across the years. Multivariable regression estimated the effect of diabetes and covariates on total annual spending among beneficiaries with cancer from 2006–2012.

Key findings From 2006 to 2012, 4918 beneficiaries included in MCBS had cancer, with over 25% (1275) also having diabetes. From 2006 to 2012, the mean economic burden of diabetes was $7815 per capita annually. After adjusting for covariates, beginning in 2006, diagnosis of diabetes significantly predicted higher total annual spending among cancer beneficiaries in 2007 [coefficient (SE) = 0.5768 (0.1918), $P = 0.003$], 2011 [coefficient (SE) = 0.4303 (0.1817), $P = 0.018$] and 2012 [coefficient (SE) = 0.3605 (0.1758), $P = 0.040$].

Conclusions Medicare beneficiaries with cancer experienced a higher economic burden from concurrent diabetes.

Keywords: medicare; cancer; diabetes; economic burden

Introduction

Older adults have the highest prevalence of multiple chronic conditions and largest healthcare spending among the entire US population.[1, 2] Cancer and diabetes are two burdensome conditions commonly affecting these older adults. The incidence of cancer is highest among older adults (≥65 years old) covered by Medicare, accounting for over half of all new cancer diagnoses.[3, 4] Similarly, the prevalence of diabetes is highest among older adults (≥65 years old) at 26.8%.[5] The high incidence and prevalence of cancer and diabetes, respectively, drastically impact the US healthcare expenditure. Healthcare spending for cancer care has increased to $150.8 billion annually as of 2018, which leads to affordability concerns as barriers to providing high-quality care and innovative cancer treatments.[6, 7] As for diabetes, healthcare spending has increased across time from $174 billion in 2007 to $245 billion in 2012 and finally $327 billion in 2017, which results in an average $1 in $7 of healthcare spending attributed to caring for diabetes.[8–11] Higher healthcare expenditures among older adults are attributed to the severity and frequency of diabetes-related complications, higher hospitalization rates and nursing home stays.[2, 12–14] Thus, cancer and diabetes are both burdensome chronic conditions affecting older adults and US healthcare expenditures.

The burden of diabetes in cancer patients is critical when considering the relationship between cancer and diabetes. Patients with diagnosed diabetes have been found to have an increased risk of cancer.[15, 16] This association of diabetes and cancer has been proposed to be related to hyperglycemia, through increased cancer cell proliferation, inhibition of cancer cell apoptosis and increased cancer cell metastasis.[17–20] Patients with cancer, including pancreatic, kidney, liver, gallbladder, lung, blood, breast, stomach and thyroid cancers, also have higher incidence rates of diabetes.[21] Proposed mechanisms behind this cancer and diabetes association include hyperglycemia induced by cancer or its treatments,[21–24] but recent data suggest that related risk factors do not explain the association between cancer and diabetes.[21] The common diagnosis and co-existence of cancer and diabetes is particularly alarming due to worse mortality (i.e. lower survival rate[17, 25]) and morbidity (i.e. increased risk of macrovascular and microvascular complications[12, 17]) outcomes for cancer patients with diabetes.

The potential impact of the economic burden of diabetes among cancer patients' care and outcomes is also cause for concern. Compared to non-cancer patients, cancer patients are faced with a higher economic burden of chronic conditions, including diabetes, pointing to a potential vulnerability during these patients' care.[26] Patients with diabetes have a higher financial need due to increased medical visits, medications and diabetes-related complications,[27] which can drain a large portion of their annual incomes.[28] The financial distress associated with overall stress, anxiety and ability to cope experienced by cancer patients would only be expected to grow in magnitude with the presence of diabetes, which significantly increases the likelihood of economic depletion and debt among cancer patients.[4, 7] The high economic burden from cancer and diabetes could also lead to adverse treatment effects when patients abandon, delay, modify, or slow treatment to financially cope, thereby worsening health outcomes.[7, 29]

Based on the rates of cancer and diabetes among older adults and the potential negative clinical and humanistic impacts of high economic burden, an investigation of the economic burden faced by older adults with cancer and diabetes is needed. However, research gaps remain among older populations with diabetes,[30] and economic evaluation to quantify the economic burden of diabetes among older adults with cancer has yet to be completed to our knowledge. Therefore, the objective of this study was to assess the economic burden of diabetes among Medicare beneficiaries with cancer by analyzing annual total costs, annual medical costs and annual prescription costs. We hypothesized that the economic burden would be significantly different in patients with cancer and diabetes compared to those with cancer only.

Methods

Study design and data source

We conducted a retrospective, serial cross-sectional study using the Medicare Current Beneficiary Survey (MCBS) database from 2006–2012. MCBS was selected as the optimal data source to answer our research question based on its central areas of healthcare utilization and economics among the Medicare population, who are at increased risk of cancer and diabetes based on their older age. MCBS is coordinated annually by the Office of Enterprise Data and Analytics (OEDA) of the Centers for Medicare and Medicaid Services (CMS).[31] MCBS combines both administrative and survey data, and data are released through either public use files or limited access data. For this study, we used the Cost and Use files from the limited access data, and 2006–2012 data years were used based on data availability and the data use agreement at the primary author's institution. We used data files required to calculate annual direct costs from administrative claims data, including inpatient, outpatient, physician services, skilled nursing facility, hospice expenditure, durable medical equipment and pharmacy condensed files. Our study protocol was approved by the institutional review board at the primary author's institution.

Sample

Medicare beneficiaries are included in MCBS for a continuous period, reaching maximum participation of four years.[32] Medicare beneficiaries include US adults aged 65 years or older and adults less than 65 years old with disabilities. To be eligible for inclusion in our study, beneficiaries were required to be currently or previously diagnosed with cancer, 65 years of age or older, non-institutionalized and continuously enrolled annually in Medicare Parts A, B and D. Beneficiaries enrolled in Medicare Advantage plans were not eligible for inclusion due to the inability to capture their medical care utilization and cost information from administrative claims. Patients with end-stage renal disease (ESRD) were included in the sample as long as they were 65 years of age or older.

Our population of interest was persons with a current or past cancer diagnosis of any type, stratified by diagnosed diabetes (including both type 1 diabetes and type 2 diabetes). Patient diagnosis of cancer and diabetes was determined through either self-report or administrative claims. Using both survey and administrative claims data from MCBS has shown more beneficial to achieve adequate representation of the target population.[33] Self-report of cancer was collected from all survey questions asking whether the person had ever been told they have cancer of any type. Self-report of diabetes was collected from the survey question asking whether the person had ever been told that they had diabetes or high blood sugar. Patients with gestational diabetes were excluded from the sample. From administrative claims data, the chronic condition warehouse algorithm for ICD-9 codes was used to identify both cancer (colorectal, endometrial, breast, lung, and prostate) and diabetes diagnosis.[34] To ensure diagnosed disease rather than flagging a routine testing for disease, at least two outpatient claims or one inpatient claim was required.

Measures

The primary outcome was the total economic burden of diabetes, which was operationalized as the difference in annual total direct costs per capita between cancer patients with and without diabetes. Annual total direct costs were calculated by adding the annual medical costs from administrative claims and the annual pharmacy costs from pharmacy claims. Secondary outcomes were the economic burden of diabetes attributed to medical care and the economic burden of diabetes attributed to prescriptions. The economic burden of diabetes attributed to medical care was operationalized as the difference in annual medical costs per capita between cancer patients with and without diabetes, and annual medical costs were calculated by summing the direct costs from claims filed through Medicare Parts A and B, including the following administrative claims files: inpatient, outpatient, physician services, skilled nursing facility, hospice expenditure and durable medical equipment. The economic burden of diabetes attributed to prescriptions was operationalized as the difference in annual prescription cost per capita between cancer patients with and without diabetes, and annual prescription costs were calculated from the pharmacy condensed files, containing all prescription claims filed through Medicare Part D. To control for inflation, all dollar values in different years were converted to the year 2012 constant dollars using the medical cost for the Consumer Price Index for All Urban Consumers annual total direct cost per capita.[35]

Statistical analysis

Baseline characteristics of beneficiaries were determined from their first year of inclusion in the sample. Characteristics between cancer beneficiaries with and without diabetes were compared using *t*-tests for continuous variables and chi-square for categorical variables. Simple linear regression was used to analyze trends of the annual total cost, medical cost and prescription cost across years among beneficiaries with diabetes, without diabetes and the cost difference between patients with and without diabetes. A multivariable regression model was used to estimate the effect of diabetes and covariates (i.e. variables related to beneficiary characteristics that could influence differences in costs) on total annual spending among beneficiaries with cancer from 2006–2012; the original total annual spending was used from each year before inflation was accounted for. In the model, cost was transformed with gamma distribution, and the log link function was used. A repeated statement accounted for correlations among persons included across multiple years. An interaction term between diabetes and year was also included in the model to test for differences between years. The cross-sectional weighting variable was applied to each beneficiary in the sample to produce estimates representative of the general Medicare beneficiary population. The a priori level of significance for statistical tests was set at $P < 0.05$. SPSS Statistics, version 25.0 (IBM Corp, Armonk, NY) and SAS, version 9.4 (SAS Institute, Cary, NC) were used for statistical analyses.

Results

Population characteristics

From 2006 to 2012, 4918 beneficiaries included in the MCBS had cancer, and over 25% of those beneficiaries (1275) also experienced diabetes. See Table 1. Cancer beneficiaries with and without diabetes had significantly different baseline characteristics, such as age, sex and marital status ($P < 0.05$). Higher proportions of cancer beneficiaries with diabetes were minorities (including non-Hispanic black, Hispanic and other racial groups) compared to cancer beneficiaries without diabetes ($P = 0.031$). The majority of cancer beneficiaries with diabetes had low income levels (<$25 000) while the majority of cancer beneficiaries without diabetes had high income levels (≥25 000; $P < 0.001$). More cancer beneficiaries without diabetes had education (high school graduate or more than high school) compared to those with diabetes ($P < 0.001$). Cancer beneficiaries without diabetes reported better general health status, lower count of limitations in activities of daily living (ADL) and less low-income subsidies ($P < 0.001$). Body mass index (BMI) for cancer beneficiaries without diabetes was mostly normal (39.5%) or overweight (38.9%), while those with diabetes were mostly overweight (37.7%) or obese (40.2%). Most chronic conditions, including hypertension, ischemic heart disease, heart failure, hyperlipidemia, chronic obstructive pulmonary disease (COPD) and ESRD were more prevalent in cancer beneficiaries with diabetes than those without; however, osteoarthritis was more prevalent in cancer beneficiaries without diabetes ($P < 0.001$ for all). Beneficiaries without diabetes were more likely to report diagnoses of skin cancers ($P = 0.007$), whereas beneficiaries with diabetes were more likely to report diagnoses of non-skin cancers ($P = 0.040$). Specifically, beneficiaries with diabetes were significantly more likely to report having uterus, stomach and kidney cancers ($P < 0.05$ for all). While some beneficiaries reported multiple cancers, the mean number of cancer types was the same for those with and without diabetes.

Total annual cost

From 2006 until 2012, the total annual cost trended downward for cancer beneficiaries with and without diabetes. See Figure 1, part A. Cancer beneficiaries with diabetes had an average total annual cost per capita ranging from a high of $34 540 in 2007 to a low of $18 891 in 2010, and the trend in cost across years decreased significantly ($P = 0.011$). Cancer beneficiaries without diabetes had an average total annual cost per capita ranging from a high of $25 126 in 2006 to a low of $12 703 in 2012, and the trend in cost across years also decreased significantly ($P < 0.001$). However, the economic burden of diabetes, or the difference in cost between beneficiaries with and without diabetes, remained constant across 2006–2012. When averaging across years, the mean total economic burden of diabetes among cancer beneficiaries was $7815.

Medical cost

Because medical cost makes up a large portion of the total direct cost in health care, results for trends in medical cost for cancer beneficiaries with and without diabetes are similar to the total annual cost. See Figure 1, part B. Cancer beneficiaries with diabetes had an average annual medical cost per capita ranging from a high of $29 323 in 2007 to a low of $13 785 in 2012, and the trend in cost across years decreased significantly ($P = 0.008$). Cancer beneficiaries without diabetes had an average annual medical cost per capita ranging from a high of $21 023 in 2006 to a low of $9807 in 2011, and the trend in cost across years also decreased significantly ($P < 0.001$). However, the economic burden of diabetes attributed to medical care, or the difference in cost between beneficiaries with and without diabetes, again remained constant across 2006–2012. When averaging across years, the mean total economic burden of diabetes attributed to medical care among cancer beneficiaries was $5808.

Table 1 Baseline characteristics of medicare beneficiaries with cancer, stratified by evidence of diabetes

Beneficiary characteristics	Cancer patients with diabetes *N* = 1275 *N* (%)	Cancer patients without diabetes *N* = 3643 *N* (%)	*P*-value*
Age			<0.001
65–74	530 (41.57)	1344 (36.89)	
75–84	567 (44.47)	1518 (41.67)	
85+	178 (13.96)	781 (21.44)	
Sex			0.031
Male	560 (43.92)	1474 (40.46)	
Female	715 (56.08)	2169 (59.54)	
Race/ethnicity			<0.001
Non-Hispanic white	1121 (87.92)	3383 (92.86)	
Non-Hispanic black	83 (6.51)	145 (3.98)	
Hispanic	34 (2.67)	48 (1.32)	
Other	37 (2.90)	67 (1.84)	
Income level			<0.001
<$25 000	742 (58.20)	1767 (48.50)	
$25 000+	533 (41.80)	1876 (51.50)	
Education level			<0.001
No high school	195 (15.37)	359 (9.89)	
Some high school	211 (16.63)	457 (12.59)	
High school graduate	343 (27.03)	1026 (28.26)	
More than high school	520 (40.98)	1788 (49.26)	
Marital status			0.011
Single	214 (16.78)	491 (13.48)	
Married	626 (49.10)	1813 (49.77)	
Widowed	435 (34.12)	1339 (36.76)	
Census region			0.159
Northeast	189 (14.82)	560 (15.37)	
Midwest	290 (22.75)	869 (23.85)	
South	550 (43.14)	1504 (41.28)	
West	220 (17.25)	666 (18.28)	
Other or missing	26 (2.04)	44 (1.21)	
Urban/rural status			0.583
Rural	387 (30.35)	1076 (29.54)	
Urban	888 (69.65)	2567 (70.46)	
Low-income subsidy	366 (28.71)	636 (17.46)	<0.001
Medicare supplemental insurance	902 (70.75)	2598 (71.31)	0.699
Self-reported general health status			<0.001
Not applicable	10 (0.78)	13 (0.36)	
Excellent/very good	372 (29.18)	1808 (49.63)	
Good	452 (35.45)	1111 (30.50)	
Fair	303 (23.76)	521 (14.30)	
Poor	138 (10.82)	190 (5.22)	
Body mass index (BMI)			<0.001
Underweight	22 (1.73)	131 (3.60)	
Normal	259 (20.36)	1436 (39.47)	
Overweight	480 (37.74)	1414 (38.87)	
Obese	511 (40.17)	657 (18.06)	
Diabetes complications and comorbidities			
Hypertension	1091 (85.57)	2441 (67.01)	<0.001
Ischemic heart disease	374 (29.33)	741 (20.34)	<0.001
Heart failure	201 (15.76)	290 (7.96)	<0.001
Hyperlipidemia[1]	583 (70.07)	1195 (51.09)	<0.001
COPD	312 (24.47)	718 (19.71)	<0.001
Osteoarthritis	301 (23.61)	1062 (29.15)	<0.001
Count of limitations in activities of daily living (ADL)[2]	0.99 ± 1.42	0.63 ± 1.23	<0.001
Comorbidity count[2]	2.24 ± 1.25	1.77 ± 1.16	<0.001
End stage renal disease	17 (1.33)	14 (0.38)	<0.001
Cancer type (self-report)			
Skin	705 (55.29)	2173 (59.65)	0.007
Non-skin	694 (54.43)	1861 (51.08)	0.040
Lung	39 (3.06)	113 (3.10)	0.939
Colorectal	100 (7.84)	234 (6.42)	0.083

Table 1 Continued

Beneficiary characteristics	Cancer patients with diabetes *N* = 1275 *N* (%)	Cancer patients without diabetes *N* = 3643 *N* (%)	*P*-value*
Breast	180 (14.12)	503 (13.81)	0.783
Uterus	65 (5.10)	138 (3.79)	0.043
Prostate	111 (8.71)	376 (10.32)	0.097
Bladder	32 (2.51)	93 (2.55)	0.933
Ovary	25 (1.96)	60 (1.65)	0.459
Stomach	25 (1.96)	36 (0.99)	0.007
Cervix	17 (1.33)	57 (1.56)	0.559
Kidney	29 (2.27)	38 (1.04)	0.001
Brain	9 (0.71)	23 (0.63)	0.776
Throat	22 (1.73)	56 (1.54)	0.643
Back	6 (0.47)	22 (0.60)	0.586
Head	14 (1.10)	50 (1.37)	0.457
Female organs	8 (0.63)	30 (0.82)	0.491
Other	120 (9.41)	312 (8.56)	0.358
Type not reported	57 (4.47)	103 (2.83)	0.004
Total count of cancer types (self-report)[2]	1.18 (0.57)	1.18 (0.54)	0.903
Year of induction			0.305
2006	140 (10.98)	405 (11.12)	
2007	164 (12.86)	538 (14.77)	
2008	139 (10.90)	361 (9.91)	
2009	91 (7.14)	303 (8.32)	
2010	271 (21.25)	790 (21.69)	
2011	224 (17.57)	609 (16.72)	
2012	246 (19.29)	637 (17.49)	

[1]Variable not available until 2009, so this interpretation should consider the large portions of missing data. [2]Mean±SD. *Chi-square and *t*-tests.

Prescription cost

Trends in prescription costs were different among cancer beneficiaries with and without diabetes. See Figure 1, part C. Cancer beneficiaries with diabetes had an average annual prescription cost per capita, ranging from a high of $5787 in 2009 to a low of $4348 in 2010, and the trend in cost did not significantly change across years. Cancer beneficiaries without diabetes had an average annual prescription cost per capita ranging from a high of $4103 in 2006 to a low of $2868 in 2012, and the trend in cost across years decreased significantly in these patients ($P = 0.014$). The economic burden of diabetes attributed to prescriptions, or the difference in cost between beneficiaries with and without diabetes, showed an increasing trend from 2006–2012, but this was not significant. When averaging across years, the mean total economic burden of diabetes attributed to prescriptions among cancer beneficiaries was $2006.

Economic burden of diabetes across years

Beginning from 2006, diabetes predicted significantly higher total annual spending compared to not having diabetes among cancer beneficiaries in 2007, 2011 and 2012 [coefficient (SE) = 0.5768 (0.1918), $P = 0.003$; 0.4303 (0.1817), $P = 0.018$; and 0.3605 (0.1758), $P = 0.040$], respectively. There were no significant interactions between diabetes and year in 2008–2010. See Table 2. Men had significantly higher total annual spending than women [coefficient (SE) = 0.2147 (0.0690), $P = 0.002$]. There was no effect of race/ethnicity on total annual spending. Cancer beneficiaries with only high school education had significantly lower total annual spending compared to cancer beneficiaries with more than high school education [coefficient (SE) = –0.1379 (0.0638), $P = 0.031$]. Compared to cancer beneficiaries living in the South, cancer beneficiaries living in the West or other region had significantly lower total annual spending [coefficient (SE) = –0.2647 (0.0721), $P < 0.001$, and –0.8216 (0.2055), $P < 0.001$], respectively. Cancer beneficiaries living in rural areas had significantly higher total annual spending than cancer beneficiaries living in urban areas [coefficient (SE) = 0.1575 (0.0701), $P = 0.025$]. Cancer beneficiaries without Medicare supplemental insurance had significantly lower total annual spending than cancer beneficiaries with Medicare supplemental insurance [coefficient (SE) = –0.7975 (0.0652), $P < 0.001$]. Compared to cancer beneficiaries self-reporting excellent/very good general health status, cancer beneficiaries with worse general health status, including good, fair and poor, had significantly higher total annual spending [coefficient (SE) = 0.4153 (0.0588), $P < 0.001$; 0.5959 (0.0701), $P < 0.001$; and 1.1616 (0.1073), $P < 0.001$], respectively. Additional chronic conditions, including ischemic heart disease, heart failure and osteoarthritis, resulted in significantly higher total annual spending [coefficient (SE) = 0.1234 (0.0565), $P = 0.029$; 0.2146 (0.0631), $P < 0.001$; and 0.2095 (0.0754), $P = 0.005$], respectively. Lastly, cancer beneficiaries with higher limitations in ADL had significantly higher total annual spending [coefficient (SE) = 0.0688 (0.0175), $P < 0.001$], and cancer beneficiaries with concurrent ESRD had significantly higher total annual spending [coefficient (SD) = 1.5288 (0.1427), $P < 0.001$].

Discussion

Our findings indicate a higher economic burden of diabetes in Medicare beneficiaries with cancer in more recent years (2007, 2011 and 2012) compared to the earliest year of data available (2006). The average economic burden across years was $7815, which equates to $9378 in 2019 when accounting for the inflation rate of 1.20 from 2012 dollars to 2019 dollars. About 74% of the average economic burden across years was attributed to medical care, with

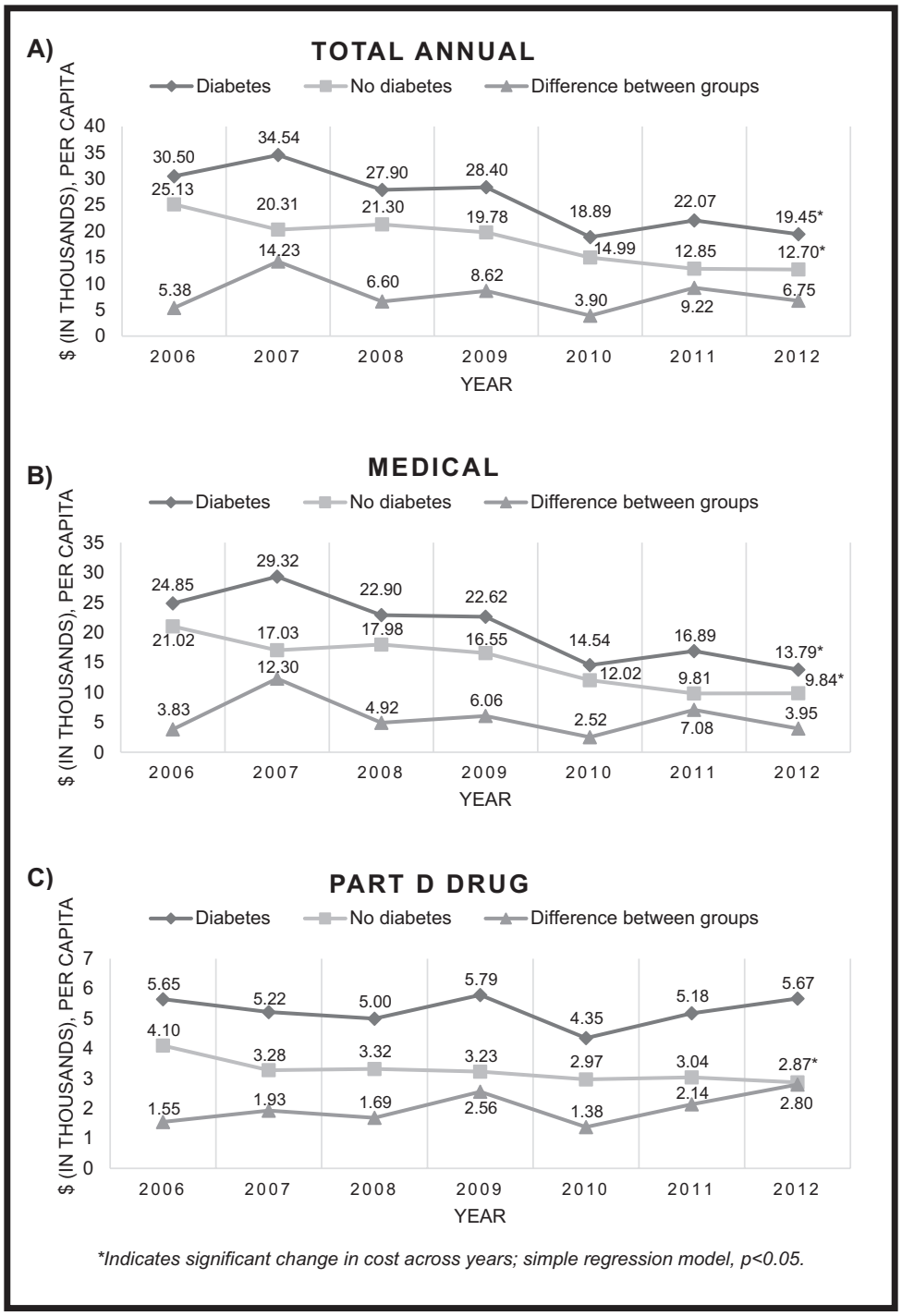

Figure 1 Trend of annual spending among medicare beneficiaries with cancer, stratified by evidence of diabetes. Part A) Total Annual; Part B) Medical; Part C) Part D Drug.

the remaining 26% attributed to prescriptions. While prescriptions accounted for a smaller portion of the economic burden than medical care, cost trends from 2006–2012 demonstrated that the higher economic burden of diabetes in more recent years was likely due to higher prescription drug costs because medical care costs for beneficiaries with and without diabetes decreased overtime. When considering other potential confounders, diabetes diagnosis remained a significant predictor of total annual healthcare spending in Medicare beneficiaries with cancer. Many subgroups of Medicare beneficiaries also experienced higher total annual healthcare spending, such as men; persons living in the South and rural areas; persons with higher than high school education, Medicare supplemental insurance, lower general health status and more limitations in ADL; and persons with comorbid conditions like ischemic heart disease, heart failure, osteoarthritis and ESRD.

These findings match previously published literature with higher costs seen in areas with higher rates of diabetes.[12, 27, 28] The South correlates with obesity and is therefore expected to have higher rates of diabetes, poorer cancer outcomes, increased complications and higher medical costs.[36] In rural areas faced with barriers to medical care (i.e. financial limitations, communication barriers, trust in receiving quality care, etc.[37]), the higher economic burden found

Table 2 Estimated effect of diabetes and covariates on total annual spending among beneficiaries with cancer

Variable	Estimated coefficient (standard error), *P*-value
Evidence of diabetes[1]	−0.1124 (0.1426), *P* = 0.430
Interaction between evidence of diabetes[1] and year	
2006 (ref)	
2007	0.5768 (0.1918), *P* = 0.003
2008	0.2316 (0.1897), *P* = 0.222
2009	0.2631 (0.1740), *P* = 0.131
2010	0.1022 (0.1905), *P* = 0.592
2011	0.4303 (0.1817), *P* = 0.018
2012	0.3605 (0.1758), *P* = 0.040
Age	
65–74 (ref)	
75–84	0.0007 (0.0602), *P* = 0.991
85+	0.0818 (0.0822), *P* = 0.320
Sex	
Male	0.2147 (0.0690), *P* = 0.002
Female (ref)	
Race/ethnicity	
Non-Hispanic white (ref)	
Non-Hispanic black	0.0930 (0.1044), *P* = 0.373
Hispanic	0.2975 (0.1891), *P* = 0.116
Other	−0.0845 (0.1405), *P* = 0.548
Income level	
<$25 000 (ref)	
$25 000+	0.0742 (0.0696), *P* = 0.286
Education level	
No high school	−0.1231 (0.0969), *P* = 0.204
Some high school	−0.1514 (0.0997), *P* = 0.129
High school graduate	−0.1379 (0.0638), *P* = 0.031
More than high school (ref)	
Marital status	
Single	0.0543 (0.0809), *P* = 0.502
Married (ref)	
Widowed	0.0722 (0.0696), *P* = 0.239
Census region	
Northeast	0.0778 (0.0891), *P* = 0.382
Midwest	−0.1241 (0.0756), *P* = 0.101
South (ref)	
West	−0.2647 (0.0721), *P* < 0.001
Other	−0.8216 (0.2055), *P* < 0.001
Urban/rural status	
Rural	0.1575 (0.0701), *P* = 0.025
Urban (ref)	
Low-income subsidy[1]	−0.1208 (0.0671), *P* = 0.072
Medicare supplemental insurance[2]	−0.7975 (0.0652), *P* < 0.001
Self-reported general health status	
Not applicable	0.9814 (0.2041), *P* < 0.001
Excellent/very good (ref)	
Good	0.4153 (0.0588), *P* < 0.001
Fair	0.5959 (0.0701), *P* < 0.001
Poor	1.1616 (0.1073), *P* < 0.001
Body mass index (BMI)	
Underweight	0.1417 (0.1548), *P* = 0.360
Normal (ref)	
Overweight	−0.1165 (0.0645), *P* = 0.071
Obese	−0.0218 (0.0859), *P* = 0.799
Diabetes complications and comorbidities	
Hypertension[2]	−0.0650 (0.0652), *P* = 0.319
Ischemic heart disease[1]	0.1234 (0.0565), *P* = 0.029
Heart failure[1]	0.2146 (0.0631), *P* < 0.001
COPD[1]	0.0908 (0.0519), *P* = 0.081
Osteoarthritis[1]	0.2095 (0.0754), *P* = 0.005
Count of limitations in activities of daily living (ADL)	0.0688 (0.0175), *P* < 0.001
End-stage renal disease[1]	1.5288 (0.1427), *P* < 0.001
Year	
2006 (ref)	
2007	−0.0915 (0.1276), *P* = 0.473
2008	−0.0025 (0.1425), *P* = 0.986
2009	−0.0726 (0.1249), *P* = 0.561
2010	−0.1161 (0.1466), *P* = 0.428
2011	−0.2768 (0.1264), *P* = 0.029
2012	−0.2502 (0.1285), *P* = 0.052

[1]Binomial variable: yes or no (ref). [2]Binomial variable: yes (ref) or no.

among rural versus urban cancer beneficiaries could be attributed to increased complications from not obtaining appropriate, preventative care. To further support our findings, a higher economic burden would be expected in the presence of comorbid conditions, lower general health status and limitations in ADL, which coincides with existing literature.[12, 27, 28] The higher economic burden among beneficiaries with Medicare supplemental insurance plans may be explained by beneficiaries seeking more care based on their lower out-of-pocket spending,[38] or beneficiaries may seek coverage from Medicare supplemental insurance plans based on their expectations of future, high healthcare spending.

Our findings may indicate that the higher economic burden of diabetes over time among Medicare beneficiaries with cancer and diabetes was driven by increasing costs of prescription medications. Prescription medications accounted for over one-quarter of healthcare spending in this population. The differential distribution of cancer types could serve as an explanation for this higher economic burden of diabetes over time. Beneficiaries with cancer and diabetes were significantly more likely to report diagnoses of non-skin cancers than skin cancers. While overall treatment costs are higher for non-skin cancers than skin cancers, prescription medication costs also account for a considerably larger portion of these treatment costs for non-skin cancers compared to skin cancers.[39] The portion of treatment costs accounted for by prescription medications has also significantly increased across time (from 2002–2006 until 2007–2011) for non-skin cancers, but the portion has remained the same for skin-cancers.[39] As for the distribution of non-skin cancers, we also found that beneficiaries with diabetes were more likely to report uterine, stomach and kidney cancers than beneficiaries without diabetes. Thus, the high cost of prescription medications for these cancer types might serve as further explanation for the higher economic burden of diabetes found over time, but further research is warranted to investigate this possibility.

Building on previous findings of diabetes being the most costly chronic condition,[2] the growing economic burden of diabetes in Medicare beneficiaries with cancer could impact health outcomes through its influence on diabetes care. Further, our finding of the constantly high cost of prescription medications may be a strong influencer of poorer outcomes as a result of patients limiting the number of medications they fill due to cost so that these patients could experience worse health outcomes from inadequate care or uncontrolled disease states.[29] More research is required to fully understand the relationship between the economic burden of diabetes and health outcomes among cancer patients. To optimize diabetes care, healthcare providers are recommended to routinely engage in conversations with patients about challenges to medication adherence,[40] including patients' healthcare-related financial limitations, so these challenges and their potential effects on outcomes can be proactively mitigated. Healthcare providers and researchers can utilize the factors uncovered in this study to identify older cancer patients most likely facing high economic burdens from diabetes, where most, if not all factors would be accessible from patient information documented in electronic health records.

Based on the demonstrated magnitude of the economic burden of diabetes experienced by Medicare beneficiaries with cancer in this study, potential strategies to minimize this burden are necessary. For instance, prevention is one strategy to reduce the economic burden by decreasing the risk of diabetes and its related complications, such as cardiovascular disease, retinopathy, neuropathy, nephropathy and mortality from cancer.[12] Prevention strategies could target factors known to increase the risk of developing/worsening diabetes. For example, nutrition could be targeted in Medicare beneficiaries because a diet of fruits, vegetables, fish and whole-grain has shown reductions in the development of diabetes.[18] Another example is the metabolic correction that has demonstrated improvements in clinical outcomes (including A1C) and reductions in costs among patients with diabetes.[41] These strategies, such as counseling by healthcare providers to educate cancer patients about diabetes care, could reduce the considerable economic burden of diabetes identified in this study. Further research in implementing real-world strategies along with rigorous assessment of the effects on healthcare spending and health outcomes could maximize future diabetes care among Medicare beneficiaries with cancer.

Limitations

While this study applied rigorous methods, limitations remain. The secondary nature of the database prevented us from analyzing variables not included in the database. Persons with Medicare Advantage plans were also not able to be included in the study based on their exclusion of administrative claims files, which would prevent us from capturing their annual costs. Therefore, findings may not be generalizable to the entire Medicare population. However, the application of weighting to the sample maximizes the representativeness of findings and estimates to the Medicare population covered by fee-for-service plans. The cross-sectional design may also be considered as a limitation because patients were not directly followed across years, but the repetition of persons across years was accounted for in the regression model. Lastly, this study is limited based on the years of data analyzed, which was determined by the availability of data at the author's institution. Despite these limitations, our findings of the economic burden of diabetes in Medicare beneficiaries with cancer from 2006–2012 have been discussed in the context of today's dollar value after accounting for inflation across time, and findings will inform clinical practice and research in diabetes care among older patients with cancer.

Conclusion

Medicare beneficiaries with cancer experience substantial economic burden from concurrent diabetes. This study contributes to the existing research gap among older populations with diabetes. With older Medicare beneficiaries accounting for over half of new cancer diagnoses and experiencing rates of diabetes that more than double the national prevalence, estimation of their economic burden was needed to fill this research gap. Our study contributes knowledge to the field of health services research through two major contributions: (1) reporting the economic burden trends between total annual, medical and prescription costs and (2) identifying subgroups of Medicare beneficiaries that experience larger magnitudes of the economic burden. Finding ways to reduce the economic burden of diabetes while providing patients with the most effective care should be a point of advocacy in the medical profession. Further research on prevention and other strategies are promising efforts to minimize the clinical and financial impact of diabetes among older adults.

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Author Contributions

Study conceptualization was completed by Chou. Data analysis and interpretation was collaboratively performed by all authors. Code was written by McDaniel with assistance from Chou. Chou supervised the formal investigation. The first draft of the manuscript was primarily written by McDaniel with assistance from Rockwell. All authors commented on, reviewed, and edited previous versions of the manuscript. All authors read and approved the final manuscript.

Conflict of Interest

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