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The economic burden of progressive chronic kidney disease among patients with type 2 diabetes ☆

Suma Vupputuri [a,*], Teresa M. Kimes [b], Michael O. Calloway [c], Jennifer B. Christian [d], David Bruhn [c], Alan A. Martin [c], Gregory A. Nichols [b]

[a] The Center for Health Research, Kaiser Permanente Georgia, Atlanta, GA
[b] The Center for Health Research, Kaiser Permanente Northwest, Portland, OR
[c] GlaxoSmithKline, US Health Outcomes, Research Triangle Park, NC
[d] GlaxoSmithKline, Clinical Effectiveness & Safety, Research Triangle Park, NC

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ABSTRACT

Aims: To estimate the rate of progression of chronic kidney disease (CKD) among patients with type 2 diabetes (T2D) and calculate medical costs associated with progression.
Methods: We conducted a retrospective cohort study of 25,576 members at Kaiser Permanente who had T2D and at least one serum creatinine measurement in 2005. Using estimated glomerular filtration rate (eGFR), we assigned patients to baseline stages of kidney function (stage 0–2, >60 ml/min/1.73 m^2, n = 21,008; stage 3, 30–59, n = 3,885; stage 4, 15–29, n = 683). We examined all subsequent eGFRs through 2010 to assess progression of kidney disease. Medical costs at baseline and incremental costs during follow-up were assessed.
Results: Mean age of patients was 60.6 years, 51% were men, and mean diabetes duration was 5.3 years. At baseline, 17.9% of patients with T2D also had stage 3 or 4 CKD. Incremental adjusted costs that occurred over follow-up (from baseline) was on average $4569, $12,617, and $33,162 per patient per year higher among patients who progressed from baseline stage 0–2, stage 3, and stage 4 CKD, respectively, compared to those who did not progress. Across all stages of CKD, those who progressed to a higher stage of CKD from baseline had follow-up costs that ranged from 2 to 4 times higher than those who did not progress.
Conclusions: Progression of CKD in T2D drives substantial medical care costs. Interventions designed to minimize decline in progressive kidney function, particularly among patients with stage 3 or 4 CKD, may reduce the economic burden of CKD in T2D.

1. Introduction

The presence of chronic kidney disease (CKD) is characterized by reduced kidney function (estimated glomerular filtration rate [eGFR] <60 ml/min/1.73 m^2) or albuminuria and affects more than 40% of US adults with either diagnosed or undiagnosed diabetes according to the 1999–2006 National Health and Nutrition Examination Surveys (Bakris, 2011; Koro, Lee, & Bowlin, 2009; Plantinga, Crews, Coresh, et al., 2010; US Renal Data System, 2010; Vupputuri, Nichols, Lau, Joski, & Thorp, 2011). In the general insured US population, the presence of CKD approximately doubles annual medical care costs (Smith, Gullion, Nichols, Keith, & Brown, 2004). Among patients with type 2 diabetes, who already have medical costs at least twice as high as the general population (Brown, Nichols, Glauber, & Bakst, 1999; Selby, Ray, Zhang, & Colby, 1997), the presence of CKD substantially increases medical costs and is one of the most expensive complications of diabetes (Brown, Pedula, & Bakst, 1999; Pelletier et al., 2008). The US Renal Data System reported that patients aged 65 years and older with both CKD and diabetes accounted for 26% of the total Medicare diabetes costs in 2009, totaling $18 billion. This cost is 11 times higher than that seen in 1993. The enormous current economic burden of CKD in type 2 diabetes seems to be on a worsening trajectory considering that the prevalence of diabetes is projected to reach 33% (affecting 29 million Americans) by 2050 if recent trends in incidence rates continue (Boyle, Thompson, Gregg, Barker, & Williamson, 2010).

Few contemporary studies have examined the progression of CKD and its associated economic costs among patients with type 2 diabetes. Furthermore, when the costs associated with CKD in diabetes are estimated, they often include the very high costs of dialysis, thus over estimating the relationship of CKD and its costs

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* Corresponding author. Center for Health Research/Southeast, Kaiser Permanente Georgia, 3495 Piedmont Rd, Building 10, Suite 101, Atlanta, GA 30305.
E-mail address: Suma133@hotmail.com (S. Vupputuri).

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prior to advancement to end-stage renal disease (ESRD) (Laliberte, Bookhart, Vekeman, et al., 2009). The economic burden of pre-dialysis CKD progression has not been well studied.

The dual objectives of this study among adult patients with type 2 diabetes were to: (1) estimate the rate of progression of CKD at different stages; and (2) calculate the medical costs associated with CKD progression at different stages.

2. Methods

2.1. Study population

Kaiser Permanente Northwest (KPNW) and Georgia (KPGA) are integrated health care delivery systems serving approximately 480,000 and 235,000 members, respectively, around the Portland, Oregon, and Atlanta, Georgia, metropolitan areas. Both organizations maintain electronic medical records (EMR) and other electronic databases that capture nearly 100% of their members' medical care utilization. All data utilized in this current study came from the EMR. KPNW and KPGA also use similarly designed diabetes registries, with entrance criteria including an inpatient or outpatient diagnosis of diabetes, dispensing of an anti-hyperglycemic drug, or a fasting glucose value >125 mg/dl. Combining data from KPNW and KPGA, we identified 43,559 individuals who had 12 months of health plan eligibility in 2005. To ensure we were studying patients with type 2 diabetes, we excluded 6424 who had insulin dispensed within the first year of entry into the KP diabetes registries (i.e. we excluded patients who were taking insulin within a year of their initial diabetes diagnosis). All patients were required to have at least one serum creatinine (SCr) measurement in 2005, the baseline year, which we considered the index kidney function measure. If progression of CKD did not occur then at least one additional SCr measurement in 2006 or later was required. If progression of CKD did occur, then at least two additional SCr measurements at least 90 days apart were necessary to confirm the follow-up estimated glomerular filtration rate (eGFR) <60 ml/min/1.73 m^2 (eGFR defined below). This latter requirement excluded 11,218 patients. Because we were focused on CKD prior to end-stage renal disease, we excluded an additional 331 patients who had a history of dialysis treatment, a previous kidney transplant, or had an eGFR <15 ml/min/1.73 m^2 during 2005. The final study sample included 25,586. Patients were followed until they died, left the health plan, or until December 31, 2010.

2.2. Study variables

We assessed eGFR using the Modification in Diet in Renal Disease (MDRD) formula (KDOQI, 2007):

$$\text{eGFR} = 186.3 \times (\text{serum creatinine level})^{-1.154} \times \text{age}^{-0.203} \times (0.742 \text{ if female}) \times (1.212 \text{ if black})$$

Then, we used eGFR to assign patients to baseline stages of CKD based on the Kidney Disease Outcomes Quality Initiative (KDOQI) as follows (National Kidney Foundation, 2007):

Stage 0/1: >90 ml/min/1.73 m^2,
Stage 2: 60–89 ml/min/1.73 m^2,
Stage 3: 30–59 ml/min/1.73 m^2, for at least 90 days
Stage 4: 15–29 ml/min/1.73 m^2, for at least 90 days

We used the MDRD formula because it is reported automatically to Kaiser Permanente healthcare providers when a serum creatinine test is ordered and is therefore the measure of kidney function likely used by physicians for disease management decisions. (However, in sensitivity analyses, the use of the CKD Epi equation to calculate eGFR resulted in trivial reclassification of CKD stage.) Since the specificity of values of the MDRD eGFR above 60 ml/min/1.73 m^2 is poor and because we did not use evidence of microalbuminuria, we combined patients with no CKD, stage 1 CKD, or stage 2 CKD into a single category. Two or more eGFRs <60 ml/min/1.73 m^2 at least 90 days apart were required to assign patients to stage 3 or 4 CKD. The study index date was defined as the date of the first GFR measure in 2005; the baseline year was 2005; and the post-index period defined what we called our follow-up period. We examined all available eGFRs through the end of 2010 to assess progression of CKD. We assessed age, sex, race and duration of diabetes (i.e. number of years in the KP diabetes registry) in 2005. Clinical measures, including body mass index, blood pressure, A1C, low density lipoprotein cholesterol (LDL-C) and estimated glomerular filtration rate (eGFR), were evaluated using the means of all values recorded during the baseline year.

The presence of diabetes-related comorbidities was assessed from visit records in the baseline year. These included cardiovascular disease (ICD-9-CM codes 410.x–414.x), cerebrovascular disease (430.x, 431.x, 432.x, 434.x, 435.x, 436.x, 437.1), heart failure (428.x), retinopathy (362.01, 362.02, 362.10), neuropathy (354.2, 354.3, 355.2, 355.3, 355.6, 355.79, 355.9, 356.9, 357.1, 357.4, 357.9) and depression (296.2, 296.3, 300.4, 309.1, 311). We also determined the use of anti-hyperglycemic, anti-hypertensive, and statin medications from pharmaceutical dispensings during the baseline year.

2.3. Progression of CKD

We defined progression as the first time an eGFR was recorded in a stage higher than the baseline stage, but progression from stage 0–2 to stage 3 or higher required a confirmatory measurement at least 90 days later. Progression to ESRD (stage 5 CKD) was assessed from EMR diagnoses of dialysis or transplantation, or GFR <15 ml/min/1.73 m^2.

2.4. Costing methods

The main analysis was direct medical care costs associated with the progression of CKD. We estimated this association in two ways. First, we calculated inpatient, outpatient, pharmacy, and total direct medical costs incurred over the entire follow-up period, comparing individuals who progressed from their baseline CKD stage to a higher stage with those who did not progress. To account for differential follow-up times, we annualized the costs by summing them, dividing by months of health plan eligibility and multiplying by 12. Second, we examined annualized costs among patients who progressed to a higher CKD stage, comparing costs prior to progression with costs incurred following progression.

Total direct, inpatient, outpatient, and pharmacy medical costs were calculated for each individual during their entire follow-up period. We based our costing method on procedures developed and validated by the Kaiser Permanente Northwest (KPNW) Center for Health Research (Hornbrook et al., 1998). This costing algorithm, which assigns an average cost per unit of service based on general ledger information, was then applied to data at KPGA. For outpatient costs, this method creates standard costs for office visits by specialty/department and type of clinician (MD vs. Physician Assistant/Nurse Practitioner). The number of visits per department per clinician type was then multiplied by the appropriate unit cost. Pharmaceutical costs were based on retail prices within the service area. Hospitalization costs were assigned to diagnosis-related groups (DRGs) based on the primary reason for hospitalization. The average daily rate per DRG was then multiplied by the length of stay. Costs for medical services incurred at facilities not owned by KPNW/KPGA were based on the amount paid to the non-plan provider. These methods ensure that while the costs reported herein may be specific to KPNW/KPGA, they approximate the charges a non-member would be billed if these same services were purchased from KPNW/KPGA. All costs were adjusted to 2010 dollars using the medical or pharmaceutical component of the Consumer Price Index.