Published in final edited form as:
J Am Geriatr Soc. 2012 April ; 60(4): 644–651. doi:10.1111/j.1532-5415.2012.03907.x.

Receipt of Diabetes Monitoring in Older Adults with Co-Morbid Dementia

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Abstract

Background/Objectives—In diabetes patients with co-morbid dementia, continued monitoring of HbA1c, cardiovascular risk, and diabetes complications can inform treatment decisions and minimize further declines in cognition, function, and quality of life. However, a clinically dominant, symptomatic, and discordant condition such as dementia may inhibit efforts to monitor diabetes in accordance with guidelines for older, complex patients. We examined the extent to which receipt of recommended diabetes monitoring differed for patients with and without co-

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Prior Presentation: This work was presented at the 63rd Annual Scientific Meeting of the Gerontological Society of America, November 19–23, 2010, New Orleans, LA.

Disclaimer: The views expressed in this article are those of the authors and do not necessarily reflect the position or policy of the Department of Veterans Affairs or the United States government.

Conflict of Interest: The editor in chief has reviewed the conflict of interest checklist provided by the authors and has determined that the authors have no financial or any other kind of personal conflicts with this paper.

Author Contributions: C. Thorpe participated in study concept and design, acquisition of data, analysis and interpretation of data, and preparation of the manuscript. J. Thorpe, A. Kind, C. Bartels, and C. Everett participated in study concept and design, interpretation of data, and preparation of the manuscript. M. Smith participated in study concept and design, acquisition of data, interpretation of data, and preparation of the manuscript. The authors would also like to thank Colleen Brown with the University of Wisconsin Health Innovation Program for assistance with editing of the manuscript, and Robert Purvis with the University of Wisconsin Health Innovation Program for assistance with creation of the analytic dataset.

morbid dementia, as well as the effect of other co-morbidities on diabetes monitoring in patients with co-morbid dementia.

Design—Retrospective cohort study.

Setting—Secondary analysis of 2005–2006 claims and enrollment data for a 5% national random sample of Medicare beneficiaries.

Participants—288,805 Medicare fee-for-service beneficiaries with a diabetes diagnosis prior to 2006; 44,717 (16%) of whom had evidence of co-morbid dementia in claims.

Measurements—We used established algorithms to determine whether patients received at least one HbA1c test, one LDL cholesterol test, and one annual eye exam in 2006, and construct variables representing co-morbidities common in diabetes, socio-demographics, and patterns of health care utilization.

Results—In unadjusted and fully adjusted models, the presence of dementia reduced patients' likelihood of receiving HbA1c tests, LDL tests, and eye exams, with effects being smallest for HbA1c tests. The effects of other co-morbidities on diabetes monitoring in patients with dementia varied by the nature of the co-morbidity and the specific test.

Conclusion—Dementia reduces the likelihood that diabetes patients received recommended annual monitoring for diabetes. More research is needed to understand reasons for reduced monitoring in this patient subgroup and how this impacts patient functioning, adverse events, and quality of life.

Keywords

diabetes; dementia; guideline adherence; care quality; Medicare

INTRODUCTION

Twenty-seven percent of adults aged 65+ have diabetes and 14% over age 70 have dementia,[1] and both conditions are expected to become more prevalent in coming years.[2,3] There is also mounting evidence that diabetes may directly increase one's risk of developing dementia.[4] Given that annual costs of diabetes and Alzheimer's disease amount to $174 billion and $183 billion, respectively, supporting improved care quality in patients who simultaneously have both conditions is of critical importance.

The presence of co-morbid dementia presents considerable challenges for diabetes management. Treatment guidelines by the American Diabetes Association (ADA) and the American Geriatrics Society (AGS) acknowledge that for older patients with dementia, the risks (e.g., adverse drug events, falls) and discomforts associated with intensive control of diabetes and its complications may outweigh benefits (e.g., reduced cardiovascular disease risk, complications), especially if life expectancy is limited.[5,6] Both guidelines recommend an individualized, shared decision-making approach to diabetes management and allow for less stringent control of hemoglobin A1c and cardiovascular risk factors; e.g., A1c level of 8% rather than 7%. The AGS guidelines also note a lack of evidence regarding the appropriate frequency of monitoring of glycemic control, lipids, and diabetes complications (e.g., retinopathy) for older, frail patients, including those with dementia, and suggest that a less intense monitoring schedule may be appropriate. However, the AGS guidelines, largely based on expert consensus, maintain that a minimum of at least one annual A1c test and biannual or annual monitoring of lipids and eye diseases, depending on patients' risk level, is necessary in order to inform treatment decisions.

Although monitoring may be appropriately discontinued if providers, caregivers, and patients agree that it would negatively impact the patient's overall quality of life, there are considerable potential benefits of continued diabetes monitoring in dementia patients at earlier stages of the disease. For example, regular monitoring of A1c can identify extremely high or low A1c levels and inform adjustments to treatment to prevent hospitalizations and specific adverse events, including diabetic ketoacidosis, hypoglycemia, dehydration, poor wound healing, and worsened cognitive and visual impairment.[5] Regular eye exams can identify progression of visual impairments that may exacerbate cognitive and behavioral symptoms of dementia, and limit quality of life.[5] Although there is less evidence about the appropriate intensity with which cholesterol levels should be treated in patients with geriatric syndromes,[5,6] continued monitoring and management of LDL cholesterol has the potential to reduce cardiovascular events, hospitalizations, and further declines in functional status. Finally, monitoring of both lipids and glycemic control may be particularly important for patients with co-morbid dementia who are taking atypical anti-psychotics for behavioral symptoms and are at increased risk for worsened metabolic status.[7,8]

Despite these potential benefits, Piette and Kerr's influential framework[9] for understanding the impact of co-morbidity on diabetes management suggests that co-morbid dementia may reduce patients' receipt of recommended diabetes monitoring. According to their model, co-morbidities, such as dementia, that are clinically dominant, involve treatment or self-management that is discordant from that required for diabetes, or are highly symptomatic may dominate clinical encounters and shift attention away from diabetes care. The allowance in treatment guidelines for less stringent diabetes control may also lead providers to de-prioritize diabetes monitoring. Furthermore, in patients with early dementia who are self-managing diabetes or whose cognitive impairment is under-appreciated by providers, diabetes monitoring may be less frequent due to the patient's reduced executive functioning and resulting non-adherence. Although prior studies among long-term care patients[10,11] suggest that the presence of co-occurring dementia may reduce patients' receipt of recommended diabetes monitoring, the effect of a dementia diagnosis among community-dwelling diabetes patients is unknown. Other studies suggest that in vulnerable elders, the presence of multiple conditions – even when discordant – may actually increase patients' receipt of recommended chronic care services by increasing contacts with the health care system.[9,12] Thus, understanding whether a dementia diagnosis leads to reduced receipt of diabetes monitoring tests is an important unanswered question.

This study addresses this gap among a national sample of Medicare beneficiaries with diabetes by examining the extent to which receipt of annual hemoglobin A1c tests, LDL cholesterol tests, and eye exams differed for patients with and without co-morbid dementia. As a further test of Piette and Kerr's framework, we also examined the relationship of other co-morbidities common in diabetes to likelihood of receiving diabetes monitoring in the subgroup of patients with co-morbid dementia.

RESEARCH DESIGN AND METHODS

Setting and Participants

The University of Wisconsin Minimal Risk Institutional Review Board approved this study with a waiver of HIPAA authorization. We used 2005–2006 Chronic Conditions Warehouse (CCW) claims and enrollment data from the Centers for Medicare and Medicaid Services (CMS) for a 5% national random sample to identify a sample of Medicare fee-for-service beneficiaries with diabetes aged 65+ as of January 1, 2005. To identify patients with diabetes, we used a validated algorithm[13] requiring patients to have at least one inpatient or skilled nursing facility (SNF) claim or more than one professional services claim associated with an *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9-

CM) code of 250.xx, 357.2, 362.0x, or 366.41 in a two-year period; we also included 648.0x (maternal diabetes mellitus complicating pregnancy, childbirth, or the puerperium). To ensure that all patients had diabetes prior to assessment of receipt of diabetes monitoring in 2006, we included only those whose first diabetes claim occurred before January 1, 2006. Beneficiaries with railroad or Medicare HMO benefits or without Medicare Parts A and B continuously over 2005–2006 were excluded. Patients who died before the end of 2006 or were hospitalized for >30 days in 2006 were excluded to reduce inclusion of end-stage dementia patients in their final days of life for whom discontinuation of monitoring may be more appropriate, and to decrease bias from reduced follow-up time to observe diabetes monitoring in claims.

Measures

We assessed patients' receipt of three diabetes care processes in 2006 consistent with guidelines specifically for older, complex patients with diabetes[6] and methods used in prior research.[14,15] Specifically, we used outpatient facility and carrier claims for 2006 to create indicators for receipt of ≥1 HbA1c test and receipt of ≥1 LDL cholesterol,[14] and carrier, outpatient facility, or inpatient facility claims to create an indicator for receipt of ≥1 eye exam[15] (see Table 1). We also created an indicator for whether patients received all three tests.

To identify patients with dementia, we used the CCW chronic condition flag for ever having met criteria for Alzheimer's Disease or Related Disorders (ADRD) or Senile Dementia over 1999–2006 in the Chronic Condition Summary File (see Table 1). Although the validity of this definition has not been directly evaluated, it contains only minor operational differences from the Medicare claims-based algorithm developed by Taylor and colleagues.[16,17] Using a national, non-clinical sample of older adults representing the full range of cognitive ability, the Taylor algorithm has demonstrated good sensitivity (0.85) and specificity (0.89) when compared to a gold-standard clinical dementia assessment.[17]

We created variables indicating the presence of other co-morbidities and complications common in diabetes. We used the 2005 end-of-year condition indicators in the Chronic Conditions Summary file to classify patients with regard to the presence of ischemic heart disease (IHD), congestive heart failure (CHF), stroke/transient ischemic attacks (TIA), and depression. We applied an established algorithm to inpatient, SNF, and carrier claims to identify patients with chronic kidney disease (CKD),[18] and then used the end-stage renal disease (ESRD) indicator in the 2005 Beneficiary Summary file to further classify patients as those with ESRD, non-ESRD kidney disease, and no kidney disease. We also applied a validated algorithm to create indicators for the presence of lower extremity ulcers, amputation, peripheral vascular disease [PVD], and combined eye diseases including background retinopathy, macular edema, and proliferative retinopathy.[19] Finally, we used the Beneficiary Summary File to create an indicator for original entitlement for Medicare due to disability.

We used the Beneficiary Summary file to capture patient socio-demographics, including sex, race/ethnicity (re-coded into white, black, or Other/unknown), age in years (65–69, 70–74, 75–79, 80–84, or 85+), and state of residence. The Medicaid state buy-in indicator was used as a proxy for patient income. Patient zip code was used to classify participants' geographic location with regard to US Department of Agriculture census-based Rural Urban Commuting Area (RUCA) codes (urban core area, suburban area, large town area, and small town/isolated rural area).[20]

We used 2005 claims to calculate the Hierarchical Condition Categories (HCC) community risk score, an established measure of predicted future health care utilization based on all

diagnoses recorded in professional services/carrier and inpatient/outpatient facility claims,[21] and categorized patients into quartiles of HCC risk. We chose the HCC score for risk adjustment over the Charlson[22–24] or Elixhauser[25] co-morbidity measures because of its inclusion of the full spectrum of diagnoses rather than a select group, and evidence of stronger ability to predict mortality.[26] We also created indicators for any hospitalization in 2005 using the inpatient facility file. To create indicators for a nursing home stay in 2005 and 2006, we searched carrier claims for evaluation and management (E&M) codes for use with patients residing in a nursing home.[27]

Analytic Approach

Analyses were conducted using Stata version 11.0 (StataCorp LP, College Station, TX). We examined descriptive statistics for all variables and used chi-square tests to assess differences by dementia status. To determine the effect of a dementia diagnosis on diabetes monitoring, we estimated separate logistic regression models for each individual diabetes test as well as all three tests. We estimated adjusted predicted probabilities based on the recycled predictions approach using Stata's "margins" command. The delta method was used to calculate 95% confidence intervals, which allows for correlation among observations. We computed adjusted risk ratios to allow for more intuitive characterization of the effect of dementia diagnosis on receipt of diabetes monitoring.[28] Finally, we limited the sample to diabetes patients with co-morbid dementia (N=44,260) and used logistic regression to estimate associations of additional co-morbidities on receipt of each individual and all three tests, controlling for socio-demographics, overall HCC risk score, and hospital and nursing home utilization. Missing RUCA values (<1% missing) were handled via listwise deletion and all regression models used robust estimates of variance.

RESULTS

Table 2 shows characteristics 288,805 Medicare beneficiaries with diabetes, overall and by dementia status. We identified 44,717 (15.5%) patients with co-morbid dementia. Over 60% of the overall sample was female, 82% were White/Caucasian, 11% were Black/African American, and over a quarter were ≥80 years old. The most common co-morbidities included IHD (47%), CHF (11%), depression (10%), and CKD (9%). Patients with dementia were more likely to be female and older, have higher HCC scores, have a hospital and nursing home stay, and have specific co-morbidities (excluding eye disease) than patients without dementia.

Eighty percent of the overall sample had ≥1 HbA1c test, 76% had ≥1 LDL test, and 62% had an eye exam, compared to just 45% receiving all three tests. Chi-square tests for raw differences in testing revealed that dementia patients were less likely to receive A1c tests (73% vs. 81%), LDL tests (61% vs. 79%), eye exams (52% vs. 63%), as well as all three tests (30% vs. 47%).

Differences in receipt of diabetes monitoring by dementia status remained statistically significant in fully adjusted models (Table 3). The adjusted predicted probability of dementia patients receiving all three tests was 36.9%, compared to 46.2% in patients without dementia (ARR=0.80, 95% CI=0.787–0.811). Patients with dementia were also less likely to receive individual tests, with the greatest difference seen for eye exams (ARR=0.85, 95% CI=0.846–0.864), followed by LDL tests (ARR=0.91, 95% CI=0.901–0.914) and A1c tests (ARR=0.96, 95% CI=0.957–0.968).

Among patients with both diabetes and dementia, individual co-morbidities were found to be significantly and heterogeneously associated with receipt of diabetes monitoring (Table 4). Eye disease, ischemic heart disease, PVD, stroke/TIA, non-end-stage kidney disease, and

depression increased likelihood of receiving at least some tests with null effects on other tests. Specifically, eye disease increased likelihood of receiving each individual test, IHD and PVD independently increased the likelihood of LDL testing and eye exams, stroke/TIA increased the likelihood of LDL testing, and depression increased likelihood of eye exams. In contrast, disability, amputation, and lower extremity ulcers each showed independent negative or null effects on receipt of diabetes monitoring, with disability consistently reducing receipt of each test. The pattern of effects for end-stage renal disease was more complex, showing positive effects on likelihood of A1c testing and negative effects LDL testing. Finally, patients in the top three quartiles of HCC risk scores had greater odds of receiving each monitoring test compared to patients in the lowest quartile, although results were strongest for A1c testing.

DISCUSSION

Despite the high prevalence of diabetes and dementia among older adults, there has been relatively little emphasis on understanding the impact of each condition on care for the other. Our research is one of the first to provide an estimate of the co-occurrence of dementia in Medicare beneficiaries with diabetes and examine the impact of dementia on diabetes care. In a national random sample of Medicare fee-for-service beneficiaries, we identified 44,717 Medicare beneficiaries aged 65 or older with a documented diagnosis of both diabetes mellitus and Alzheimer's Disease or a Related Disorder (ADRD). This represents approximately 16% of older Medicare beneficiaries with diabetes and ~894,340 patients nationally, confirming that this "natural cluster" of illnesses[29] occurs frequently enough to warrant further attention.

Our finding that a dementia diagnosis reduced diabetes monitoring adds to the literature in support of Piette and Kerr's typology of co-morbid conditions,[9,30,31] which proposes that co-morbid conditions that are clinically dominant, symptomatic, and discordant in terms of treatment in relation to diabetes would detract from its management. Our results also mirror patterns of diabetes monitoring similar to those observed for diabetes patients in long-term care settings with dementia,[10,11] as well as one study documenting lower rates of diabetic eye exams among a nationally representative sample of older adults.[32]

Although dementia was associated with decreases in all three individual types of monitoring, effects were relatively weaker for A1c testing compared to cholesterol tests and eye exams. A1c testing differs from both LDL cholesterol testing and eye exams in that it can be conducted at the point-of-care in the course of routine office visits, rather than requiring a fasting laboratory appointment (LDL cholesterol) or separate office visit (eye exam). As a result, the increased overall healthcare utilization observed for patients with dementia, as evidenced by their higher HCC risk score, may increase opportunities for testing A1c and offset other barriers introduced by the presence of dementia. Conversely, eye exams and fasting LDL tests may place a greater burden on patients and caregivers in terms of scheduling appointments and transportation, and require more cooperation from patients in completing the actual exam. Thus, our results highlight that the characteristics of specific care processes for the index condition (in this case, diabetes), such as burden on the patient, caregiver, and/or health care provider, may be important to consider in addition to characteristics of the co-morbidity when predicting its effect on the index condition. This point is further demonstrated by the lack of uniformity of effects for other specific co-morbidities on likelihood of receiving each of the three specific diabetes tests in patients with both diabetes and dementia. With the exception of disability, the presence of specific co-morbidities, as well as overall HCC risk score, either increased or had no significant effect on the likelihood that a patient with both diabetes and dementia received annual A1c monitoring. This provides further evidence that in the case of chronic disease care delivered

easily in the course of office visits, co-morbidities may provide increased opportunities for point-of-care service provision.

It is notable, and consistent with Piette and Kerr's framework regarding the importance of treatment concordance, that higher likelihood of annual LDL testing was observed in patients who had co-morbidities that are by themselves indications for cholesterol monitoring, including IHD, stroke/TIA, and PVD. Furthermore, consideration of the remaining microvascular complications of diabetes suggests positive effects on LDL testing when complications are less dominant (eye disease, non-end-stage kidney disease) and concordant, but negative effects when these complications are more dominant and/or symptomatic (ESRD, lower extremity ulcers, disability). With regard to the receipt of eye exams, co-morbidities had either positive or null effects, with the exception of amputation and disability, two very clinically dominant conditions.

Another notable finding was that our indicator of disability, defined conservatively as having been originally entitled for Medicare prior to age 65, significantly reduced one's likelihood of receiving each of the three tests. This is consistent with research documenting numerous barriers with regard to physical access, patient-provider communication, and quality of care experienced by individuals with disabilities,[33–35] and suggests that this subgroup of patients with both diabetes and dementia may be at particular risk for decreased vigilance with regard to monitoring of diabetes and its complications. Future research using more refined measures of disability should probe further the effects of different types and levels of disability on receipt of recommended diabetes care in patients with co-morbid dementia residing in community and long-term care settings.

Our results should be interpreted in light of several limitations. Most notably, our reliance on claims data to identify cases of dementia prevented us from examining the effect of dementia duration or severity on diabetes monitoring. In its early stages, dementia may present much less dominantly and be seen as relatively concordant with the goals of diabetes given the shared vascular pathophysiologic links between the two conditions. As dementia becomes more dominant and symptomatic, it may increasingly shift focus away from diabetes. As patients progress to end-stage disease or reach their last days of life, it becomes more likely that reduced monitoring may reflect a conscious, shared decision by the care team and family, and higher rather than lower quality of care. Evidence is lacking on the circumstances under which monitoring of glycemic control and diabetes complications should be completely discontinued. Future research should examine how severity of dementia affects intensity of diabetes monitoring, as well as the clinical and psychosocial risks and benefits of continued monitoring of diabetes as dementia progresses.

Relatedly, our reliance on claims data may have led to misclassification of patients' dementia status, and in particular, failure to identify some cases of mild dementia due to a tendency of a dementia diagnosis in claims to lag behind its clinical emergence.[17] However, prior research suggests that our method for identifying dementia cases using claims has good validity for identifying dementia across the spectrum of severity.[16,17] This, together with exclusion of patients who died or were hospitalized for more than 30 days in the follow-up year, makes it less likely that results are driven entirely by reduced diabetes monitoring in patients with end-stage dementia.

It is also likely that barriers to diabetes monitoring in patients with mild to moderate dementia are different for those residing in long-term care versus community settings, and different intervention approaches are needed. Although we were able to identify patients with evidence of at least some nursing home use and control for this in our analyses, our inability to determine dates of nursing home admission and discharge using Medicare Part A

and B claims limited our ability to rigorously examine differences among patients dwelling in the community versus long-term care settings. Barriers to diabetes monitoring in different care settings should be examined so that interventions tailored to these settings can be developed and tested.

Despite these limitations, our findings have important implications for future research and intervention. Most importantly, we identified dementia as a barrier to the receipt of the minimal level of annual diabetes monitoring advocated by treatment guidelines specifically developed for older, frail patients with diabetes. Although the disparity in A1c testing rates for diabetes patients with and without dementia was relatively small, the almost 10 percentage point difference in the adjusted rate of LDL testing and eye exams and 20 percentage point gap in comprehensive monitoring indicates an urgent need for efforts to better understand and inform diabetes care decisions in this population. In particular, research is needed to understand to what extent this reduction in diabetes monitoring is the result of a conscious, collaborative decision by patients, caregivers, and providers versus an unconscious de-prioritization of diabetes monitoring, and/or non-adherence by caregivers/patients. In particular, patient non-adherence may serve as a signal that dementia is not being managed sufficiently[36], or that the patients' monitoring schedule needs to be reconsidered. In addition, research is sorely needed on how results of monitoring tests are being used to inform subsequent treatment decisions and self-care recommendations (e.g., medication changes, schedules for self-monitoring blood glucose, lifestyle modification) and subsequent effects on a broad range of outcomes for patients and caregivers (e.g., regimen adherence, caregiver distress, preventable hospitalizations, health care costs). Taken together, such research would help elucidate the extent to which the substantially lower rate of diabetes monitoring in patients with co-morbid dementia indicates suboptimal care quality versus a mismatch of treatment guidelines with patient-centered care. Future work should help define what does constitute high-quality diabetes care for this vulnerable population and inform the development of interventions to support improved outcomes.

Acknowledgments

Funding Sources: Support was provided by the Health Innovation Program and the Community-Academic Partnerships core of the University of Wisconsin Institute for Clinical and Translational Research (UW ICTR), grant 1UL1RR025011 from the Clinical and Translational Science Award (CTSA) program of the National Center for Research Resources, National Institutes of Health. Additional funding for this project was provided by the UW School of Medicine and Public Health from The Wisconsin Partnership Program.

Sponsor's Role: The Health Innovation Program assisted with data collection, analysis, and manuscript formatting. No other funding source had a role in the design, methods, subject recruitment, data collection, analysis, or preparation of the paper.

References

1. Plassman BL, Langa KM, Fisher GG, et al. Prevalence of dementia in the United States: the aging, demographics, and memory study. Neuroepidemiology. 2007; 29:125–132. [PubMed: 17975326]
2. Boyle JP, Honeycutt AA, Narayan KMV, et al. Projection of diabetes burden through 2050-Impact of changing demography and disease prevalence in the US. Diabetes Care. 2001; 24:1936–1940. [PubMed: 11679460]
3. Sloane PD, Zimmerman S, Suchindran C, et al. The public health impact of Alzheimer's disease, 2000–2050: Potential implication of treatment advances. Annu Rev Public Health. 2002; 23:213–231. [PubMed: 11910061]
4. Biessels GJ, Staekenborg S, Brunner E, et al. Risk of dementia in diabetes mellitus: A systematic review. Lancet Neurol. 2006; 5:64–74. [PubMed: 16361024]
5. Standards of medical care in diabetes--2011. Diabetes Care. 2011; 34 (Suppl 1):S11–61. [PubMed: 21193625]

6. California Healthcare Foundation/American Geriatrics Society Panel on Improving Care for Elders with Diabetes. Guidelines for improving the care of the older person with diabetes mellitus. J Am Geriatr Soc. 2003; 51:S265–S80. [PubMed: 12694461]
7. Newcomer JW. Second-generation (atypical) antipsychotics and metabolic effects: A comprehensive literature review. CNS Drugs. 2005; 19 (Suppl 1):1–93. [PubMed: 15998156]
8. Johnsen E. Review: Metabolic side effects of second-generation antipsychotics. Evid Based Ment Health. 2011; 14:47. [PubMed: 21502153]
9. Piette JD, Kerr EA. The impact of comorbid chronic conditions on diabetes care. Diabetes Care. 2006; 29:725–731. [PubMed: 16505540]
10. Quinn CC, Gruber-Baldini AL, Port CL, et al. The role of nursing home admission and dementia status on care for diabetes mellitus. J Am Geriatr Soc. 2009; 57:1628–1633. [PubMed: 19682125]
11. McNabney MK, Pandya N, Iwuagwu C, et al. Differences in diabetes management of nursing home patients based on functional and cognitive status. J Am Med Dir Assoc. 2005; 6:375–382. [PubMed: 16286058]
12. Min LC, Wenger NS, Fung C, et al. Multimorbidity is associated with better quality of care among vulnerable elders. Med Care. 2007; 45:480–488. [PubMed: 17515774]
13. Hebert PL, Geiss LS, Tierney EF, et al. Identifying persons with diabetes using Medicare claims data. Am J Med Qual. 1999; 14:270–277. [PubMed: 10624032]
14. Halanych JH, Wang F, Miller DR, et al. Racial/ethnic differences in diabetes care for older veterans: Accounting for dual health system use changes conclusions. Med Care. 2006; 44:439–445. [PubMed: 16641662]
15. Arday DR, Fleming BB, Keller DK, et al. Variation in diabetes care among states: Do patient characteristics matter? Diabetes Care. 2002; 25:2230–2237. [PubMed: 12453966]
16. Taylor DH, Fillenbaum GG, Ezell ME. The accuracy of Medicare claims data in identifying Alzheimer's disease. J Clin Epidemiol. 2002; 55:929–937. [PubMed: 12393082]
17. Taylor DH Jr, Ostbye T, Langa KM, et al. The accuracy of Medicare claims as an epidemiological tool: The case of dementia revisited. J Alzheimers Dis. 2009; 17:807–815. [PubMed: 19542620]
18. Foley RN, Murray AM, Li SL, et al. Chronic kidney disease and the risk for cardiovascular disease, renal replacement, and death in the United States Medicare population, 1998 to 1999. J Am Soc Nephrol. 2005; 16:489–495. [PubMed: 15590763]
19. Newton KM, Wagner EH, Ramsey SD, et al. The use of automated data to identify complications and comorbidities of diabetes: A validation study. J Clin Epidemiol. 1999; 52:199–207. [PubMed: 10210237]
20. Washington State Department of Health. Guidelines for using rural-urban classification systems for public health assessment: A four-tier consolidation of the RUCA system at the sub-county level. Washington State Department of Health; Available at: http://www.doh.wa.gov/data/Guidelines/RuralUrban2.htm#fourtier
21. Pope GC, Kautter J, Ellis RP, et al. Risk adjustment of Medicare capitation payments using the CMS-HCC model. Health Care Financ Rev. 2004; 25:119–141. [PubMed: 15493448]
22. Charlson ME, Pompei P, Ales KL, et al. A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation. J Chronic Dis. 1987; 40:373–383. [PubMed: 3558716]
23. Charlson M, Szatrowski TP, Peterson J, et al. Validation of a combined comorbidity index. J Clin Epidemiol. 1994; 47:1245–1251. [PubMed: 7722560]
24. Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. J Clin Epidemiol. 1992; 45:613–619. [PubMed: 1607900]
25. Elixhauser A, Steiner C, Harris DR, et al. Comorbidity measures for use with administrative data. Med Care. 1998; 36:8–27. [PubMed: 9431328]
26. Li P, Kim MM, Doshi JA. Comparison of the performance of the CMS Hierarchical Condition Category (CMS-HCC) risk adjuster with the Charlson and Elixhauser comorbidity measures in predicting mortality. BMC Health Serv Res. 2010; 10:245. [PubMed: 20727154]
27. Koroukian SM, Xu F, Murray P. Ability of Medicare claims data to identify nursing home patients: A validation study. Med Care. 2008; 46:1184–1187. [PubMed: 18953230]

28. Kleinman LC, Norton EC. What's the risk? A simple approach for estimating adjusted risk measures from nonlinear models including logistic regression. Health Serv Res. 2009; 44:288–302. [PubMed: 18793213]

29. Katon, W. Complex Medical Patients (presentation). AHRQ 2010 Annual Conference; 2010 September 27; Rockville, MD. Available at: http://www.ahrq.gov/about/annualconf10/katon/katon2.HTM

30. Kerr EA, Heisler M, Krein SL, et al. Beyond comorbidity counts: How do comorbidity type and severity influence diabetes patients' treatment priorities and self-management? J Gen Intern Med. 2007; 22:1635–1640. [PubMed: 17647065]

31. Sales AE, Tipton EF, Levine DA, et al. Are co-morbidities associated with guideline adherence? The MI-Plus Study of Medicare Patients. J Gen Intern Med. 2009; 24:1205–1210. [PubMed: 19727967]

32. Sloan FA, Brown DS, Carlisle ES, et al. Monitoring visual status: why patients do or do not comply with practice guidelines. Health Serv Res. 2004; 39:1429–1448. [PubMed: 15333116]

33. Iezzoni LI, McCarthy EP, Davis RB, et al. Mobility impairments and use of screening and preventive services. Am J Public Health. 2000; 90:955–961. [PubMed: 10846515]

34. Iezzoni LI. Going beyond disease to address disability. N Engl J Med. 2006; 355:976–979. [PubMed: 16957143]

35. Iezzoni LI, Killeen MB, O'Day BL. Rural residents with disabilities confront substantial barriers to obtaining primary care. Health Serv Res. 2006; 41:1258–1275. [PubMed: 16899006]

36. Feil DG, Lukman R, Simon B, et al. Impact of dementia on caring for patients' diabetes. Aging Ment Health. 2011; 15:894–903. [PubMed: 21547750]

Table 1

Codes Used to Identify Diabetes Care Processes and Alzheimer's Disease or Related Disorder (ADRD)

Care Process	Description
HbA1c tests	CPT codes on carrier or outpatient facility claims: 83036 or 83037
LDL cholesterol tests	CPT codes on carrier or outpatient facility claims: 83721, 80061, 83715, 83716, 83700, 83701, or 83704, or a combination of 82465, 83718, and 84478 on the same claim
Eye exams	CPT codes on carrier, outpatient, or inpatient claims: 67101, 67105, 67107, 67108, 67110, 67112, 67141, 67145, 67208, 67210, 67218, 67227, 67228, 92002, 92004, 92012, 92014, 92018, 92019, 92225, 92226, 92230, 92235, 92240, 92250, 92260 CPT codes on carrier claims associated with a provider specialty code of 18 (ophthalmology) or 41 (optometry): 99201–99215, 99241–99245 ICD-9-CM procedure codes on acute inpatient claims: 14.21, 14.22, 14.23, 14.24, 14.25, 14.26, 14.27, 14.29, 14.31, 14.32, 14.33, 14.34, 14.35, 14.39, 14.41, 14.49, 14.51, 14.52, 14.53, 14.54, 14.55, 14.59, 14.9, 95.02, 95.03, 95.04, 95.11, 95.12, 95.16
Diagnosis of Alzheimer's Disease or Related Disorder (ADRD)	ICD-9-CM diagnosis code in any position on at least 1 inpatient, skilled nursing facility, home health, hospital outpatient, or carrier claim: 331.0, 331.1, 331.11, 331.19, 331.2, 331.7, 290.0,290.1, 290.10, 290.11, 290.12, 290.13, 290.20, 290.21,290.3, 290.40, 290.41, 290.42, 290.43, 294.0, 294.1,294.10, 294.11, 294.8, 797

HbA1c = Hemoglobin A1c; LDL = Low-density lipoprotein; CPT = Current Procedural Technology; ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification

Table 2

Characteristics of 288,805 Medicare Beneficiaries with Diabetes, by Dementia Status

Characteristic	Overall	Dementia (n=44,717)	No Dementia (n=244,088)	P-Value
% with Dementia	15.5			
Socio-demographics (%)				
Female	60.8	67.9	59.5	<.01
Race				<.01
White	82.0	79.0	82.6	
Black	11.2	13.6	10.8	
Other/Unknown	6.7	7.5	6.6	
Age				<.01
65–69	26.0	9.3	29.0	
70–74	25.4	16.8	27.0	
75–79	22.8	24.1	22.6	
80–84	16.2	26.0	14.4	
85–89+	9.7	23.8	7.1	
Rural/Urban				<.01
Small Town or Isolated Rural Area	12.6	11.5	12.8	
Large Town Area	12.9	12.0	13.1	
Suburban Area	9.6	8.6	9.8	
Urban Core Area	63.9	67.0	63.3	
Missing	1.0	1.0	1.0	
Medicaid Buy-in	19.9	35.7	17.0	<.01
Baseline Co-morbidities (%)				
Ischemic heart disease	46.7	55.3	45.1	<.01
Congestive Heart Failure	10.6	18.7	9.1	<.01
Stroke/TIA	5.9	14.8	4.2	<.01
Chronic Kidney Disease				<.01
None (ref)	90.6	86.9	91.2	
Non-ESRD CKD	8.2	11.6	7.6	
ESRD	1.2	1.5	1.2	
Depression	10.3	25.5	7.5	<.01
Lower Extremity Ulcers	1.7	3.2	1.5	<.01
Amputation	0.4	0.8	0.3	<.01
Eye Disease	1.3	1.2	1.3	0.60
PVD	7.5	9.7	7.1	<.01
Entitled due to disability	10.5	12.4	10.2	<.01
Health Care Utilization (%)				
Baseline HCC Risk Score (2005)				<.01
Quartile 1	25.2	7.7	28.4	
Quartile 2	24.9	17.9	26.2	
Quartile 3	24.9	28.3	24.3	

Characteristic	Overall	Dementia (n=44,717)	No Dementia (n=244,088)	P-Value
Quartile 4	25.0	46.1	21.1	
Hospitalized in 2005	27.1	42.9	24.2	<.01
Nursing home stay in 2005	8.4	32.2	4.1	<.01
Nursing home stay in 2006	9.4	36.3	4.4	<.01
Receipt of Diabetes Monitoring Tests in 2006 (%)				
At least 1 A1c test in 2006	79.7	73.3	80.8	<.01
At least 1 LDL test in 2006	76.2	60.6	79.1	<.01
At least 1 eye exam in 2006	61.6	52.2	63.3	<.01
All 3 tests	44.7	30.4	47.4	<.01

TIA = Transient ischemic attack; ESRD = End-stage renal disease; CKD = Chronic kidney disease; PVD = Peripheral vascular disease; HCC = Hierarchical Condition Category; LDL = Low-density lipoprotein

Table 3

Adjusted Predicted Probabilities and Risk Ratios for Effect of Dementia Diagnosis on Receipt of Recommended Diabetes Tests in 2006 (N=286,038)*

Care Process	Adjusted Predicted Probability (%)	95% CI	Adjusted Risk Ratio	95% CI
Receipt of ≥1 A1c test in 2006				
Dementia	77.4	(76.9, 77.8)	0.96	(0.96, 0.97)
No Dementia (ref)	80.4	(80.2, 80.5)		
Receipt of ≥1 LDL test in 2006				
Dementia	70.3	(69.9, 70.8)	0.91	(0.90, 0.91)
No Dementia (ref)	77.5	(77.3, 77.7)		
Receipt of ≥1 eye exam in 2006				
Dementia	54.0	(53.4, 54.5)	0.85	(0.85, 0.86)
No Dementia (ref)	63.1	(62.9, 63.3)		
Receipt of all three tests in 2006				
Dementia	36.9	(36.4, 37.4)	0.80	(0.79, 0.81)
No Dementia (ref)	46.2	(46.0, 46.4)		

* Models adjusted for gender, race/ethnicity, age, Medicaid buy-in, disability entitlement, Rural Urban Commuting Area (RUCA) code, Hierarchical Condition Category (HCC) quartile, presence of specific co-morbidities including ischemic heart disease, congestive heart failure, stroke, chronic kidney disease, depression, lower extremity ulcers, amputation, combined eye diseases, and peripheral vascular disease, hospitalization in prior year, nursing home stay in prior and current year, and state of residence.

Table 4

Association of Additional Co-Morbidities with Receipt of Recommended Diabetes Tests in 2006 by Patients with Diabetes and Co-Morbid Dementia (N=44,260)*

	Receipt of ≥1 A1c test		Receipt of ≥1 LDL test		Receipt of ≥1 eye exam		Receipt of all 3 tests	
Co-Morbidity	**ARR**	**95% CI**	**ARR**	**95% CI**	**ARR**	**95% CI**	**ARR**	**95% CI**
Ischemic heart disease	1.00	(0.99, 1.01)	1.14	(1.12, 1.16)	1.05	(1.03, 1.07)	1.14	(1.10, 1.17)
Congestive Heart Failure	1.00	(0.98, 1.01)	0.99	(0.97, 1.01)	0.98	(0.95, 1.00)	0.98	(0.94, 1.02)
Stroke/TIA	0.99	(0.97, 1.01)	1.03	(1.01, 1.05)	0.99	(0.96, 1.02)	1.00	(0.96, 1.04)
Chronic Kidney Disease								
None (ref)								
Non-ESRD CKD	1.02	(1.00, 1.04)	1.03	(1.00, 1.05)	1.02	(0.99, 1.05)	1.08	(1.03, 1.13)
ESRD	1.15	(1.11, 1.19)	0.72	(0.66, 0.79)	0.98	(0.91, 1.06)	0.74	(0.63, 0.85)
Depression	0.99	(0.98, 1.00)	1.00	(0.98, 1.01)	1.03	(1.00, 1.05)	0.97	(0.94, 1.01)
Lower Extremity Ulcers	1.00	(0.96, 1.03)	0.92	(0.88, 0.97)	0.95	(0.90, 1.01)	0.91	(0.83, 1.00)
Amputation	1.04	(0.99, 1.10)	1.05	(0.98, 1.13)	0.91	(0.82, 1.00)	0.94	(0.79, 1.09)
Eye Disease	1.16	(1.12, 1.21)	1.10	(1.03, 1.16)	1.37	(1.29, 1.44)	1.57	(1.43, 1.71)
PVD	1.01	(1.00, 1.02)	1.02	(1.00, 1.03)	1.09	(1.07, 1.11)	1.10	(1.06, 1.13)
Disability	0.94	(0.93, 0.96)	0.94	(0.92, 0.96)	0.94	(0.92, 0.97)	0.88	(0.84, 0.92)
Hierarchical Condition								
Category (HCC) Quartiles								
Quartile 1 (ref)								
Quartile 2	1.22	(1.18, 1.26)	1.07	(1.04, 1.10)	1.09	(1.04, 1.14)	1.22	(1.15, 1.29)
Quartile 3	1.22	(1.18, 1.26)	1.06	(1.02, 1.09)	1.14	(1.09, 1.18)	1.24	(1.16, 1.31)
Quartile 4	1.24	(1.19, 1.28)	1.02	(0.98, 1.06)	1.16	(1.11, 1.21)	1.23	(1.15, 1.31)

*Models adjusted for all variables shown in table, plus gender, race/ethnicity, age, Medicaid buy-in, Rural Urban Commuting Area (RUCA) code, hospitalization in prior year, nursing home stay in prior and current year, and state of residence.

ARR = Adjusted Risk Ratio; TIA = Transient ischemic attack; ESRD = End-stage renal disease; CKD = Chronic kidney disease; PVD = Peripheral vascular disease; LDL = Low-density lipoprotein