**Featured Article**

**Executive function, episodic memory, and Medicare expenditures**

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**Abstract**

Introduction: We examined the relationship between health care expenditures and cognition, focusing on differences across cognitive systems defined by global cognition, executive function, or episodic memory.

Methods: We used linear regression models to compare annual health expenditures by cognitive status in 8125 Nurses’ Health Study participants who completed a cognitive battery and were enrolled in Medicare parts A and B.

Results: Adjusting for demographics and comorbidity, executive impairment was associated with higher total annual expenditures of $1488 per person (P < .01) compared to those without impairment. No association for episodic memory impairment was found. Expenditures exhibited a linear relationship with executive function, but not episodic memory ($584 higher for every one standard deviation decrement in executive function; P < .01).

Discussion: Impairment in executive function is specifically and linearly associated with higher health care expenditures. Focusing on management strategies that address early losses in executive function may be effective in reducing costly services.

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**Keywords:** Medicare; Dementia; Cognition; Aging; Executive function; Episodic memory; Health care spending

1. Introduction

Cognitive impairment is a primary feature of many neurodegenerative diseases, including Alzheimer’s disease (AD) [1–7]. With the aging population, the prevalence of cognitive impairment is likely to increase [2,8]. Yet, the relationship between health care costs and cognitive impairment is not well understood.

Recent studies have demonstrated that a diagnosis of dementia is associated with increased health care utilization [8,9]. In 2010, Medicare costs attributable to dementia were estimated to be $11 billion [2,8,9]. To develop strategies to manage these expanding costs, it is essential to better understand this relationship. Impairment in episodic memory versus executive function may be a useful distinction. Although episodic memory is impaired early in AD, impairment in executive function often predominates in vascular disease; the two co-occur as well [3,10–12]. A second fundamental question is whether health care utilization exhibits a continuous relationship with cognitive function, or if it is not until a certain threshold level is reached when cognitive impairment begins to influence spending. Such a distinction could have important implications for timing the initiation of interventions.

In this study, we linked Medicare claims to cognitive data from the Nurses’ Health Study (NHS) to investigate the association between impairment in specific cognitive systems and health care utilization. The NHS is a large, prospective, epidemiological study of female nurses with cognitive data collected via validated telephone assessments [13,14]. We performed a cross-sectional analysis of NHS participants to evaluate the association between Medicare expenditures and global, episodic, and executive function, adjusting for

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2. Methods

2.1. Study population

The NHS is a longitudinal study of female nurses across 11 US states that began in 1976 [13]. The NHS is approved by the Partners Human Research Committee (Boston, MA, USA). From 1995 to 2001, a telephone-based cognitive assessment was initiated in subjects who were aged at least 70 years and free of stroke (93% of those eligible participated). Three follow-up assessments were performed every 2 years (with >90% follow-up rate) [15]. The final cognitive assessment was conducted from 2005 through 2008 and was completed by 8890 nurses. In this study, only cognitive data from the final assessment were used since Medicare claims data were available starting in 2006.

2.2. Cognitive assessment

The cognitive battery was administered over the telephone and included the following: Telephone Interview for Cognitive Status (TICS); a delayed recall of the TICS 10-word list; an immediate and delayed recall of the East Boston Memory Test (EBMT); digit span backwards; and category fluency (animal naming). The TICS is a telephone version of the Mini–Mental State Examination and assesses global cognitive function [16–18]. The EBMT tests paragraph recall, and the TICS 10-word list assesses word list recall [19,20]. The category fluency task and digit span backwards both assess aspects of executive function [21–23].

We used Z-scores to calculate composite scores to measure global cognitive function, executive function, and episodic memory. The global score was the mean of the Z-scores for all six cognitive tests. The episodic score was the mean of the Z-scores of the immediate and delayed recall of the TICS 10-word list and the immediate and delayed recall of the EBMT; and the executive score was the mean of the Z-scores of digit span backwards and category fluency.

2.3. Medicare expenditures and utilization

A crosswalk was generated by the Centers for Medicare and Medicaid Services to link NHS participants to their beneficiary ID on the Medicare claims held at Dartmouth. Medicare claims data were obtained for beneficiaries in 2006 through 2009 using the Standard Analytic File. Medicare expenditures were price-standardized to account for the variation in the price of services across areas [24]. Total expenditures and expenditures by category (inpatient, outpatient, physician services, home health, hospice, and durable medical equipment [DME]) were measured. Data on all-cause hospitalizations, obtained from the Medicare Provider Analysis and Review file, were also used to determine the number of hospitalizations, average length of hospital stay, and total hospital days.

2.4. Covariates

Age and race were obtained from NHS questionnaires at the time of cognitive assessment. Comorbid illnesses were obtained from the Medicare claims files using the Elixhauser comorbidity score [25]. The Elixhauser score is a summary measure of comorbidity generated from the presence of diagnoses indicated by Medicare International Classification of Disease-9 or Diagnosis-Related Groups codes. We required one inpatient claim or two outpatient claims to identify the presence of a comorbid disease. The year of utilization measurement was also included as a covariate to account for any differences in potential time trends.

2.5. Analysis

Cognitive scores for global, episodic, and executive function were the main independent variables. In initial analyses, cognitive scores were categorized as either impaired or not impaired for each domain, where impaired was defined as the worst 10% of the distribution of the study population. The primary outcome measures were annual Medicare expenditures and hospitalization rates for the year following the participant’s cognitive assessment. Unless specified otherwise, only subjects with Medicare claims data for the full year following the cognitive assessment were included. A secondary analysis was also performed to include subjects who died before the end of the year with additional adjustment for the time (in months) between the start of the claims year and date of death.

In the initial analyses, the association of Medicare expenditures with impairment in each cognitive domain (global, episodic, and executive) was tested. Multiple linear regression with heteroscedasticity-consistent standard errors was used to model expenditures as a function of cognitive status (impaired or not impaired). The association of cognitive function on expenditures was further explored by grouping cognitive scores into deciles, and marginal means were generated to estimate Medicare expenditures separately for each level of cognitive function. Finally, cognitive function (in Z-scores) was modeled as a continuous variable in a linear model.

To test the association of impairment with hospitalization rates, a generalized linear model with a Poisson distribution and log link function was used to model hospitalizations, total hospital days, and length of hospital stay as a function of cognitive status (impaired or not impaired). Because impairment in different cognitive systems may co-occur, we also created four mutually exclusive categories to represent the impairment type. Subjects were grouped into one of four categories as follows: neither episodic nor executive impairment (neither); episodic impairment but not executive impairment (episodic only); executive impairment (episodic only); executive impairment...
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