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Healthcare utilization and costs in diabetes relative to the clinical spectrum of painful diabetic peripheral neuropathy

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ABSTRACT

Aims: Diabetic peripheral neuropathy (DPN) accompanied by painful symptoms is known as painful DPN (pDPN). This study characterized healthcare resource utilization and costs in patients with DPN, pDPN, and severe pDPN relative to diabetes only.
Methods: Four adult cohorts were identified from the Humedica database: type 2 diabetes without DPN ($n = 288,328$); DPN ($n = 35,050$); pDPN (DPN subjects with a pain score ≥1 on a 0–10 numeric rating scale; $n = 3449$); and severe pDPN (pain scores 7–10; $n = 1824$). Resource utilization and costs for 12-months post-diagnosis were compared for diabetes relative to the other cohorts.
Results: Demographic characteristics were different across cohorts. Relative to diabetes alone, DPN, pDPN, and severe pDPN were characterized by significantly higher proportions of patients with resource utilization for all resource categories (all $P < 0.0001$); the highest resource use generally observed for severe pDPN. Total annual direct medical costs were $6632 for diabetes only, with costs for DPN ($12,492), pDPN ($27,931), and severe pDPN ($30,755) significantly higher (all $P < 0.0001$); outpatient costs were consistently the primary driver of total costs.
Conclusions: Patients with DPN, pDPN, and severe pDPN had significantly greater healthcare resource utilization and costs than patients with diabetes only, with the highest burden associated with severe pDPN.

1. Introduction

Diabetic peripheral neuropathy (DPN) is a common neurologic sequela of diabetes, and when the resulting nerve damage is accompanied by painful symptoms it is known as painful DPN (pDPN). The presence of pDPN is associated with a substantial adverse impact on patient function, quality of life, and work productivity, and also results in an economic burden relative to the general population and to patients with diabetes without pDPN (Benbow, Wallymahmed, & Macfarlane, 1998; daCosta DiBonaventura, Cappelleri, & Joshi, 2011; Dworkin, Malone, Panarites, Armstrong, & Pham, 2010; Dworkin, Panarites, Armstrong, Malone, & Pham, 2011; Gore et al., 2005; Ritzwoller, Ellis, Korner, Hartsfield, & Sadosky, 2009; Stewart, Ricci, Chee, Hirsch, & Brandenburg, 2007). These effects have been reported to be greater as pain severity increases (Dibonaventura, Cappelleri, & Joshi, 2011; Gore et al., 2005; Sadosky et al., 2013).

As integrated healthcare systems develop new care delivery models to manage the increasing burden of expensive chronic conditions, such as diabetes, in accord with Affordable Care Act, a deeper understanding of the clinical problems and types of care that disproportionately contribute to the high costs at the population level is required. However, there have been no studies comparing healthcare resource utilization and costs of diabetes relative to DPN, pDPN, and severe pDPN.

Electronic medical records (EMR) capture real-world, patient-level data representing integral components of provider care that are not readily available in claims databases including patient-reported outcomes such as pain severity. The availability of these data enables identification of discrete populations and evaluation of resources and costs across inpatient and outpatient settings. This characterization is essential to managed care, especially accountable care organizations, providing the background and understanding required to implement

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more targeted disease management strategies (Eggleston & Finkelstein, 2014). Therefore, the purpose of this study is to apply EMR-derived clinical information from the Humedica database to evaluate the direct medical costs of patients with diabetes relative to DPN, pDPN, and severe pDPN. This clinical database facilitates identification and management of patients with chronic conditions who are at risk for greater clinical complexity and higher costs of care.

2. Methods

2.1. Data source

Data for this retrospective study were derived from the Humedica EMR database, which has broad geographic representation and includes information on demographics, diagnoses, inpatient and outpatient encounters, medications, procedures, lab results, vital signs, and select data derived from physicians' notes. Humedica does not mandate a particular EMR system, and in the more than 20 provider groups, many run multiple EMR installations for different sites of care. Records are linked using a unique patient identifier and are fully compliant with the Health Insurance Portability and Accountability Act (HIPAA).

The current analysis utilized structured and unstructured data from the database. Structured data included demographic and clinical characteristics, and healthcare resource utilization (HCRU). Unstructured data were derived from the notes fields within the EMR, which were searched using Humedica's proprietary Natural Language Processing (NLP). The Humedica NLP system uses vocabulary from the Unified Medical Language System including multiple medical dictionaries such as the Logical Observation Identifiers Names and Codes (LOINC), the Systemized Nomenclature of Medicine–Clinical Terms (SNOMED-CT), and RxNorm, a listing of generic and branded drugs (among others). Each NLP concept included in the data is associated with a unique subject record and a date of observation, allowing longitudinal tracking.

A specific part of the search of the unstructured data was for pain scores, which are collected by Humedica as a health measure, and are patient-reported using a 0 to 10 scale (0 = no pain, 10 = worst imaginable pain). The scores are recorded during discrete health care provider interactions, although providers may use different methods, including the Visual Analogue Scale (VAS) and the Verbal Numerical Rating Scale (VNRS). These scores may be recorded in the structured data elements of the EMR or harvested from notes using NLP.

2.2. Subjects

Subjects ≥18 years of age with type 2 diabetes were identified from the database for the period January 1, 2008–September 30, 2013 based on *ICD-9-CM* diagnosis codes (250.00-250.93) in the most recent calendar year available (2008–2012) and having continuous data for 1 year pre- and post-diagnosis. Subjects were excluded if they had a diagnosis code for end-stage renal disease, cancer, and/or HIV any time during the study period, were resident in a nursing/inpatient facility in the year prior to the diabetes diagnosis, or had a pregnancy during the pre-index period. Only identified subjects who belonged to an integrated delivery network (IDN) were included.

Among subjects who met all criteria, the DPN cohort was defined as subjects with diabetes who had an *ICD-9* code for DPN (*ICD-9* codes: 357.2 or 250.6). The pDPN cohort consisted of DPN subjects with a pain score ≥1 for current pain that was obtained within 15 days (before or after) the DPN diagnosis, and the severe pDPN cohort was pDPN subjects with pain scores 7–10, indicating severe pain based on established criteria (Zelman, Dukes, Brandenburg, Bostrom, & Gore, 2005). The index date, for evaluation of healthcare resource utilization and costs, was the date of *ICD-9* diagnosis, i.e. date of diabetes diagnosis in the diabetes-only cohort, and date of DPN diagnosis in the other cohorts.

2.3. Healthcare resource utilization and costs

All-cause resource utilization, estimated as the proportion of patients using each resource category, was identified from the claims data for the 12-month post-index period. Resource categories included emergency room (ER) visits, hospitalizations, outpatient resources stratified by office visits and other outpatient visits, laboratory tests, foot procedures and total procedures, and prescriptions. Additionally, prescriptions for pain-related medications were evaluated.

All-cause costs were obtained for the subset of patients who are linked to the Optum claims database. The charged, or requested amount that is billed by the provider was used as the cost, although this number may have high variation since it often has little relationship to the actual amount paid. The Optum DataMart is an integrated database consisting of enrollment, inpatient and outpatient medical claims, pharmaceutical claims, and laboratory results.

2.4. Analyses

Baseline demographic characteristics of the cohorts were summarized descriptively, and comparisons with the diabetes cohort were performed using likelihood ratio chi-square test for categorical variables and Student's t-test for continuous variables. Proportions of patients using each resource category were compared using likelihood ratio chi-square tests. Direct medical costs were compared using Wilcoxon two-sample rank sum tests. All analyses were conducted using SAS version 9.2 (SAS Institute Inc., Cary, NC).

3. Results

3.1. Cohort populations

As shown in Table 1, the four cohorts derived from the 24,257,806 patients in the Humedica database for the specified time period consisted of 288,328 patients with diabetes only; 35,050 with DPN; 3,449 with pDPN; and 1824 with severe pDPN, which represents 52.9% of the patients with pDPN. Among the pDPN patients, there was no difference in mean (SD) pain scores collected in inpatient ($n = 1724$) and outpatient ($n = 1725$) settings, 6.4 (2.9) and 6.3 (2.6), respectively.

Significant differences were observed for most demographic characteristics between the diabetes-only cohort and the other cohorts (Table 2). In particular, there were significantly lower proportions of females in the diabetes-only cohort (53.2%) relative to pDPN (55.6%; $P = 0.005$) and severe pDPN (59.7%; $P < 0.0001$), and whereas severe pDPN patients were significantly younger than diabetes-only (59.4 vs. 61.4 years; $P < 0.0001$), DPN patients were significantly older (64.8 years; $P < 0.0001$). The proportion of smokers was also lower in the diabetes-only cohort (28.9%) relative to the other cohorts ($P < 0.0001$), which appeared to increase from DPN (34.2%) to pDPN (37.8%) to severe pDPN (39.6%).

The prevalence of comorbidities across all system classes was significantly higher with DPN, pDPN, and severe pDPN relative to diabetes-only (all $P < 0.0001$) (Table 2). The higher prevalence of neuropathic pain conditions in the DPN, pDPN, and severe pDPN cohorts was primarily driven by back and neck pain with neuropathic pain involvement, and causalgias (data not shown). Diabetes-only patients had the lowest CCI score, 1.3, with all other cohorts having significantly higher scores; 3.6, 3.9, and 3.9 for DPN, pDPN, and severe pDPN, respectively (all $P < 0.0001$ vs. diabetes-only). Diabetes-related comorbidities such as retinopathy and the CCI comorbidity of "Diabetes with chronic complications" were also significantly higher for DPN, pDPN,