Use of a medication-based algorithm to identify advanced Parkinson’s disease in administrative claims data: Associations with claims-based indicators of disease severity

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Introduction: Lack of a gold standard definition for advanced Parkinson’s Disease (APD), coupled with absence of disease severity information in diagnostic codes, hinders use of large administrative databases for conducting population health and comparative effectiveness studies.

Methods: Using pharmacy claims data, we created an algorithm to identify APD: any 30-day average levodopa equivalent dose (LED) >1000 mg/day. Using 2013 100% U.S. Medicare claims, we applied this algorithm and used multivariate logistic regression to examine associations between assigned APD status and claims-based indicators of PD severity (any deep brain stimulation, fall, hallucinations, walker, wheelchair, specialty bed, dementia diagnosis, skilled nursing facility, hospice), adjusting for sociodemographic, clinical, and treatment characteristics. Levodopa >1000 mg/day, levodopa >800 mg/day and LED >800 mg/day were used in sensitivity analysis.

Results: In our sample (N = 144,703), 20% were assigned APD status based on the LED >1000 mg/day cut-off. This group had significantly higher odds of having each claims-based indicator, compared with those assigned mild-moderate PD status. Odds ratios were highest for indicators for any DBS (OR: 2.96; 95% CI:2.75–3.19) and specialty bed (OR:1.25). Results based on alternative approaches were similar.

Conclusions: Medicare patients classified as having APD via a pharmacy claims-based algorithm had higher odds of having claims-based clinical markers of APD, compared with patients categorized as having mild-moderate PD. This proxy strategy could facilitate future claims-based studies and warrants further refinement and validation using medical records or other clinical sources.

1. Introduction

Parkinson’s disease (PD) is the second most prevalent age-related neurodegenerative disorder after Alzheimer’s disease and is associated with motor symptoms (e.g., tremor) and non-motor symptoms (e.g., dementia) [1,2]. Advancing disease is associated with increasing morbidity, fluctuations in symptom control, impairment in activities of daily living, and mortality [3]. As with other progressive conditions, disease staging is useful for treatment planning and disease management and also facilitates research aimed at understanding the burden of disease, disease progression, clinical heterogeneity, and treatment and adherence patterns. Administrative claims databases are a valuable resource for conducting such population-level studies because they offer an economical and efficient way to study large groups of patients treated in real-world settings [4]. For example, a large claims-based study could compare real-world outcomes associated with two different treatments for individuals with APD. The ability to identify patients according to severity is also a critical tool for insurers who seek to utilize administrative claims data to target patients for disease management or medication therapy management programs.

In the United States, a particularly rich research resource is administrative claims data from Medicare, a federally funded health insurance program that provides coverage to 98% of Americans who are 65 years of
age and older as well as those who are younger but meet certain disability
criteria [5,6]. Medicare data are particularly valuable to identify patients by
PD severity, given that PD most often afflicts the elderly and typically ad-
vances in severity with age, and the Medicare Part D Medication Therapy
Management Program may offer an opportunity to better manage APD pa-
tients. Yet the ability to conduct claims-based research focused on PD sev-
erness is hindered by the fact that current International Classification of Diseases
(ICD) diagnosis codes – a typical strategy for identifying patients belonging
to a specific diagnostic group – do not incorporate PD stage. There is also no
standard clinical algorithm for identifying PD stage in administrative claims
datasets, which limits their utility for studies of individuals with advanced
disease.

Efforts to develop an algorithm for identifying advanced Parkinson’s dis-
ease (APD) in claims data are complicated by several factors. First, there is
no gold standard clinical definition of APD on which to base such an algo-
rithm. Second, initial efforts to define disease progression focused primarily
on balance changes as documented by a standard rating scale (the Hoehn
and Yahr, or H&Y scale) [7], but such clinical ratings are not available in
claims data. Third, clinician approaches to documenting the presence of
complications associated with advanced disease, such as dementia, may
lead to variable sensitivity and specificity when they are used as a claims-
based proxy. On the one hand, a clinician who is concerned about a
patient’s cognitive functioning may include a diagnostic code for dementia
in the absence of a full assessment of whether the individual meets criteria
for a formal diagnosis. On the other hand, a patient who does qualify for a
dementia diagnosis but does not disclose cognitive issues during a clinical
visit may subsequently remain undiagnosed, or a provider may note symp-
toms in a medical chart but not include the diagnostic code in insurance
claims.

Despite these challenges, several studies have attempted to identify ad-
vanced disease via claims-based proxy identifiers. A study of the economic
costs of PD by Johnson and colleagues [8] distinguished newly diagnosed
individuals from those with more advanced disease based on evidence of
new claims for an ambulatory assistive device (i.e., walker or wheelchair;
proxy for H&Y stage 4). Subsequent studies also captured a subgroup de-

dined by admission to a skilled nursing facility [9] or long-term care facility
(proxy for H&Y stage 5) [10]. While informative, using medical services to
proxy APD may have more limited utility in studies requiring clinical preci-
sion. For example, while ambulatory assistive devices are more commonly
used in APD as compared to earlier in the disease process, they are not uni-
versally needed. Thus, such proxies may fail to identify a large proportion of
patients in the early stages of APD in claims data, representing a missed op-
portunity to examine real-world treatment patterns in those most likely to
benefit from targeted management of APD. At the same time, the use of am-
bulatory assistive devices in an individual with PD may be related to other
age-related comorbidities rather than PD itself, which could lead to some
earlier stage patients being misclassified as having APD.

We sought to advance efforts to detect APD in claims data in two key
ways, based on the emerging global consensus that a broader array of clin-
ical indicators is important for identifying APD [3]. First, we built an algo-
rithm using pharmacy claims only, given the easier accessibility to
prescription claims (as opposed to medical claims) data for many key stake-
holders in the U.S., including stand-alone Medicare Part D plans, prescrip-
tion benefit managers, and pharmacies. Second, in addition to refining
and testing the medication-based algorithm, we also sought to assess—for
the first time—whether disease group assignment based on the algorithm
was associated with other established clinical markers of PD severity.

2. Methods
2.1. Data source and sample

Our retrospective study utilized 2013 100% Medicare claims from the
Chronic Condition Data Warehouse, which includes all individuals in the
U.S. who are covered by fee-for-service Medicare. The dataset included
medical claims from Medicare Part A (hospital, skilled nursing facility,
limited home health services, and hospice) and Part B (outpatient hospital,
physician, physician-administered drugs, other outpatient, and durable
medical equipment); Medicare Part D prescription claims (outpatient pre-
scription drug event) files; and a personal summary file with the
beneficiary’s demographic and enrollment information.

Our analytic sample consisted of beneficiaries aged 65 or older who had
at least one inpatient or outpatient claim with a diagnosis code of PD (ICD-
9-CM code 332.0). To be included in our study (Supplementary Fig. 1), in-
dividuals had to be continuously enrolled in fee-for-service Medicare Parts
A and B as well as a stand-alone Part D (prescription drug) plan and alive
throughout the study period (i.e., the calendar year 2013). Individuals
were also required to have received levodopa treatment (at least one levo-
dopa medication claim in 2013, with or without additional treatments) and
to have complete data available for all key covariates. This approach to case
definition criteria has been shown to optimize both sensitivity and specific-
ity when using administrative claims to identify individuals with PD
[11,12].

2.2. Conceptual framework for identifying APD via medication-based proxy

As noted earlier, there is no single standard clinical definition of APD or
diagnostic test to identify it. Nonetheless, levodopa is often considered the
gold standard medication therapy for symptomatic treatment of PD [13],
and changes in its use correspond to typical changes in symptoms as the dis-
ease advances. While levodopa improves mobility and decreases disability,
the progressive neurodegeneration that occurs with advancing PD is associ-
ated with the need for higher levodopa doses to reduce symptomatic “off”
time. The medical literature, including reports of medication dosing in clin-
cial studies of patients with advanced disease, supports the idea that higher
doses of levodopa are a marker of increasing disability and serve as a proxy
for clinical features of advanced disease such as motor complications and
dyskinesias (Supplementary Table 1). Whereas more frequent levodopa
dosing has also been identified as a marker of advanced disease [3], it is dif-
ficult to confidently discern this level of detail from prescription claims
data.

Given that patients could have been taking additional medications for
their PD, we calculated levodopa equivalent doses (LEDs) in addition to
levodopa dosing. We chose dosing thresholds based on a review of dosing
reported in clinical trials of advanced therapies such as deep brain stimula-
tion (DBS), which are indicated in APD when symptoms have progressed to
motor fluctuations and increasing “off” time. Details on the individual stud-
ies included in our dosing review may be found in Supplementary Table 1.
We calculated LEDs based on a previously published algorithm from a sys-
tematic review that considered all anti-PD oral medications [14]. Our dos-
ing threshold for APD was any 30-day average LED > 1000 mg/day. To
categorize patients, we calculated the daily medication dosing for each indi-
vidual for each day in 2013 and looked for any 30-day period during the
study year when the average dosing met the threshold. Patients with
dosing satisfying this criterion were categorized as having APD. We
assigned APD status to patients who were on consistently higher doses
(e.g., 30-day average > 1000 mg/day throughout the study year) and also
those who may have received a higher dose for a shorter period of time
(e.g., one month or more). We opted for this less stringent criterion based
on the reasoning that higher doses—regardless of whether they were well-
tolerated and continued—were likely to signal advanced disease. We catego-
rized all PD patients in the final sample as having either APD or mild-
moderate PD (≤ 1000 mg/day).

2.3. PD disease severity indicators

Next, in keeping with prior studies [8,9] and recently published consen-
sus guidelines aimed at identifying clinical indicators of the transition to
APD [3], we identified multiple clinical indicators for advanced PD that
are available in administrative claims. These included presence of: 1) any
medical claim reflecting a Current Procedural Terminology (CPT) code in-
dicating current or recent DBS treatment (e.g., device placement,
programming); 2) any medical claim reflecting an ICD-9 code for a fall; 3) selected diagnostic codes for hallucinations; 4) a durable medical equipment (Part B) claim for a walker, a proxy for patients at H&Y stage 4; 5) a durable medical equipment claim for a wheelchair, also a proxy for patients at H&Y stage 4; 6) a durable medical equipment claim for a specialty bed, a proxy for patients at H&Y stage 5; 7) a medical claim containing a diagnostic code for dementia (any subtype); 8) a medical claim for care in a skilled nursing facility, indicated when inpatient rehabilitation is needed due to a decline in function; or 9) a medical claim for hospice care, indicated at end of life. Because our intention was to test our algorithm by examining generally contemporaneous markers of APD rather than to predict clinical outcomes, we captured claims for these indicators at any point during the study year.

2.4. Covariates

The covariates of interest included patient sociodemographic characteristics (age, sex, race, region); prescription drug hierarchical condition categories (RxHCC) risk score [15]; and whether patients had an outpatient claim for a neurologist visit during the study year (yes/no). The RxHCC score is a risk-adjustment score created using a series of medical condition categories coded from patients’ medical claims and has been used to adjust for comorbidities and/or potential selection biases in prior studies among Medicare patients. A higher RxHCC score indicates a higher comorbidity burden. We captured neurologist care as a covariate based on prior evidence that patients who see a neurologist are more likely to be on PD medications and may experience different rates of relevant outcomes [16,17].

2.5. Statistical analysis

For descriptive analyses, chi-square tests were used for categorical variables and t-tests were used for continuous variables. We employed logistic regressions to examine relationships between assigned APD status (as the main independent or predictor variable; reference value was mild-moderate PD) and the clinical indicators of advanced disease described above (as the dependent or outcome variables), while adjusting for relevant covariates. We hypothesized that patients classified by the medication-based algorithm as having APD would have greater odds of having known clinical indicators of greater disease severity.

Primary analyses utilized the LED >1000 mg/day threshold for identifying APD. In sensitivity analyses, we used three alternative methods of assigning APD status: 1) any 30-day average levodopa dose >1000 mg/day; 2) any 30-day average levodopa >800 mg/day and; 3) any 30-day average LED >800 mg/day. We selected the 800 mg threshold to test in sensitivity analyses because it is a less conservative cut-off for APD that was still within the range of medication dosing for APD found in our literature review. The University of Pennsylvania Institutional Review Board deemed the study exempt from informed consent procedures because no data were collected directly from patients.

3. Results

Table 1 shows sociodemographic, clinical, and treatment characteristics for our final sample of 144,703 individuals as well as group characteristics using the LED >1000 mg/day version of our algorithm. A total of 28,974 (20%) people were categorized as having APD, with the remaining 80% classified as mild-moderate PD. We found statistically significant differences across all characteristics we examined. The APD group had a lower proportion of the oldest patients (>80 years old) as compared to the mild-moderate group (34.3% vs. 49.3%, P < 0.001), and also a higher proportion of men (58.0% vs. 46.1%, P < 0.001). A greater proportion of those in the APD group had a claim for a neurologist visit during the study year (84.2% vs. 66.3%, P < 0.001), as compared to the mild-moderate PD group.

As shown in Table 2, each of the disease severity indicators we examined were more prevalent among the APD group, with the exception of dementia, which was more common in the mild-moderate group (39.2% vs. 33.6%; P < 0.001). After controlling for relevant covariates, however, the APD group had significantly higher odds of having a claim for each of our clinical indicators of disease severity (see Fig. 1). Increased odds were highest for claims related to any DBS (OR: 2.96; 95% CI: 2.75–3.19) and a specialty bed (OR: 2.15, 95% CI: 1.99–2.32) and lowest for dementia (OR: 1.21; 95% CI: 1.18–1.25) and falls (OR: 1.27; 95% CI: 1.20–1.34).

Table 1

| Characteristic | Overall (N = 144,703) | Mild-Moderate PD (n = 115,729) | Advanced PD (n = 28,974) |
|---------------|-----------------------|---------------------------------|--------------------------|
|               | N | Percent | N | Percent | N | Percent |
| Age, years    |   |         |   |         |   |         |
| < 65          | 16,702 | 11.5% | 11,964 | 10.3% | 4738 | 16.4% |
| 65–69         | 27,882 | 19.3% | 20,685 | 17.9% | 7197 | 24.8% |
| 70–74         | 33,141 | 22.9% | 26,039 | 22.5% | 7112 | 24.5% |
| ≥ 75          | 66,978 | 46.3% | 57,041 | 49.3% | 9397 | 34.3% |
| Sex           |   |         |   |         |   |         |
| Male          | 70,127 | 48.5% | 53,211 | 46.1% | 16,806 | 58.0% |
| Female        | 74,577 | 51.5% | 62,528 | 53.9% | 17,768 | 42.0% |
| Race           |   |         |   |         |   |         |
| White         | 126,830 | 87.6% | 100,878 | 87.2% | 25,952 | 89.6% |
| Black         | 6666 | 4.6% | 5860 | 5.1% | 806 | 2.8% |
| Other         | 11,207 | 7.7% | 8991 | 7.8% | 2216 | 7.6% |
| Region         |   |         |   |         |   |         |
| North         | 28,430 | 19.6% | 23,061 | 19.9% | 5369 | 18.5% |
| South         | 38,687 | 26.7% | 30,487 | 26.3% | 8200 | 28.3% |
| West          | 52,885 | 36.5% | 43,040 | 37.2% | 9845 | 34.0% |
| RxHCC score, mean (SD) | 1.48 (0.46) | 1.50 (0.46) | 1.40 (0.45) |
| Neurologist visit | 101,146 | 69.9% | 76,762 | 66.3% | 24,384 | 84.2% |

PD, Parkinson’s disease; RxHCC score, prescription drug hierarchical condition category risk score.

Table 2

| Indicator | Overall (N = 144,703) | Mild-Moderate PD (n = 115,729) | Advanced PD (n = 28,974) |
|-----------|-----------------------|---------------------------------|--------------------------|
| N | Percent | N | Percent | N | Percent |
| Any deep brain stimulationa | 3690 | 2.6% | 1880 | 1.6% | 1810 | 6.2% |
| Fall | 8099 | 5.6% | 6298 | 5.4% | 1801 | 6.2% |
| Hallucinations | 4724 | 3.3% | 3246 | 2.8% | 1478 | 5.1% |
| Walker | 7907 | 5.5% | 6250 | 5.4% | 1657 | 5.7% |
| Wheelchair | 12,784 | 8.8% | 9739 | 8.4% | 3045 | 10.5% |
| Specialty bed | 7711 | 5.3% | 5974 | 5.2% | 1737 | 6.0% |
| Dementia | 55,085 | 38.1% | 45,347 | 39.2% | 9738 | 33.6% |
| Skilled nursing facility | 374 | 0.3% | 267 | 0.2% | 107 | 0.4% |
| Hospice | 2545 | 1.8% | 1913 | 1.7% | 632 | 2.2% |

PD, Parkinson’s disease.

a Patients were classified based on an algorithm derived from prescription claims. Patients with any 30-day average levodopa equivalent dose (LED) >1000 mg/day were classified as advanced; all others were assigned mild-moderate status.

Table 2 Prevalence of clinical indicators of advanced Parkinson’s disease, by assigned disease severity group.

b Comparisons of patient subgroups for all variables listed were statistically significant at the P < 0.001 level, using chi-square tests for categorical variables and a t-test for the continuous variable.

c RxHCC scores in the overall sample ranged from 0.72 to 6.30; scores in the mild/moderate PD group ranged from 0.72 to 6.30 and scores in the APD group ranged from 0.72 to 5.33.

d Indicates patient had an outpatient claim for a neurologist visit during the study year.
This pattern of findings held across each dosing threshold we examined (Table 3). Classification based on levodopa dosing alone resulted in a slightly lower rate of APD (17% data not shown), whereas application of the lower dose cutoffs resulted in a slightly higher percentage of patients being classified as APD (27% for levodopa >800 mg/day and 30% for LED >800 mg/day; data not shown).

4. Discussion

This study builds on prior approaches to identifying individuals with advanced Parkinson’s disease (APD) in administrative claims databases [8–10,18]. Using comprehensive Medicare claims data from 2013 for individuals aged 65 or older, we tested a claims-based algorithm based on medication dosing calculated from prescription drug claims, using several dosage thresholds. For the first time in the published literature, we examined whether the disease status assigned via our algorithm was associated with a variety of claims-based clinical indicators of disease severity. Using a medication threshold of any 30-day average levodopa equivalent dose (LED) >1000 mg/day over the course of the 1-year study period, we found that approximately 20% of our sample of Medicare patients with PD were classified as having advanced disease, with the remaining 80% classified as having mild-moderate disease. The group identified as having APD had significantly higher odds of each indicator of disease severity that we examined, including having a claim for any DBS placement or treatment, one or more falls, hallucinations, a walker, a wheelchair, a specialty bed, a diagnosis of dementia, use of a skilled nursing facility, and hospice care.

It is difficult to compare our results to existing APD prevalence statistics, as findings from population-based studies of PD have varied widely due to differences in patient sampling and methodology. Among studies using

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Table 3

| APD indicators                  | Levodopa dose >1000 mg/day (n = 24,851) | Levodopa dose >800 mg/day (n = 39,631) | LED dose >800 mg/day (n = 43,790) |
|---------------------------------|----------------------------------------|---------------------------------------|----------------------------------|
| Any deep brain stimulationa     | OR (95% CI)                            | OR (95% CI)                           | OR (95% CI)                      |
| Fall                            | 2.96 (2.74–3.19)                       | 2.47 (2.30–2.66)                      | 2.41 (2.24–2.59)                 |
| Hallucinations                  | 1.24 (1.18–1.30)                       | 1.23 (1.17–1.30)                      | 1.26 (1.19–1.33)                 |
| Walker                          | 1.71 (1.61–1.82)                       | 1.63 (1.53–1.73)                      | 1.74 (1.63–1.86)                 |
| Wheelchair                      | 1.58 (1.47–1.71)                       | 1.54 (1.43–1.67)                      | 1.61 (1.47–1.75)                 |
| Specialty bed                  | 2.02 (1.91–2.13)                       | 1.93 (1.83–2.04)                      | 2.00 (1.89–2.12)                 |
| Dementia                        | 2.11 (1.96–2.27)                       | 2.04 (1.89–2.19)                      | 2.09 (1.93–2.27)                 |
| Skilled nursing facility        | 1.18 (1.15–1.22)                       | 1.20 (1.16–1.23)                      | 1.21 (1.17–1.25)                 |
| Hospice                         | 1.72 (1.39–2.12)                       | 1.62 (1.30–2.01)                      | 1.44 (1.12–1.85)                 |

APD, Advanced Parkinson’s disease; CI, confidence interval; LED, levodopa equivalent dose; OR, odds ratio.

a Dose cutoffs represent various approaches to classifying patients as having APD, based on an algorithm derived from prescription claims. Patients meeting the dose criterion indicated were classified as having advanced disease. Logistic regressions adjusted for sociodemographic characteristics (age, sex, race, region), clinical characteristics (RxHCC score), and treatment characteristics (any outpatient visit with a neurologist during study year). The reference group is those who did not meet the dosage criterion (i.e., those classified as mild-moderate status). All comparisons were significant at the P < 0.001 level, with the exception of skilled nursing facility for the levodopa dose >800 mg group (P < 0.005).

b Deep brain stimulation was defined as the presence of any CPT code indicating current or recent treatment (e.g., device placement or programming).
the fact that individuals with more comorbid conditions may be less likely to be identified as APD, and also likely re...

... approaches in identifying patients with advanced disease who had a lower 

course of a single year may lack sensitivity in these cases (i.e., miss certain cases of APD), despite the fact that we would expect it to have high specificity (i.e., a low rate of false positives for APD). One exception might be individuals with mild/moderate disease who are tremor-dominant and medication resistant, which could lead to survival during the advanced stages of PD. In addition, although our APD group had higher odds of having a dementia diagnosis as compared to the mild/moderate group, the difference between groups was smaller than might be expected. This could reflect variation in coding practices for dementia and also likely reflects the fact that patients with dementia are at increased risk for psychosis and thus may receive lower doses of levodopa [24]. Additional clinical factors may impede the tolerability of higher doses of dopaminergic therapy, such as the presence of orthostatic hypotension or dyskinesias, leading to misclassification of some APD patients as mild/moderate. An algorithm based solely on medication dose over the course of a single year may lack sensitivity in these cases (i.e., miss certain cases of APD), despite the fact that we would expect it to have high specificity (i.e., a low rate of false positives for APD). One exception might be individuals with mild/moderate disease who are tremor-dominant and medication resistant, which could lead to doses exceeding the 1000 mg/day limit and misclassification of some APD patients as medication resistant, which could lead to doses exceeding the 1000 mg/day limit and misclassification as APD. At the same time, our medication-based algorithm may have been more sensitive than other approaches in identifying patients with advanced disease who had a lower level of physical disability. For example, our APD group had a lower rate of falls (6.2%) than the rate found in a cohort of individuals with APD defined by an incident claim for an ambulatory-assistive device (31.9%) [9]. An additional strength of our approach is the ability to identify individuals with APD in databases outside the U.S. that contain pharmacy information.

Our findings should be interpreted in the context of several caveats. We examined claims data from 2013, before the U.S. Food and Drug Administration had approved additional APD treatments (i.e., continuous infusion treatments), and it would be important to include claims for these therapies in future studies examining markers of advanced disease. Our LED-based algorithm will be able to accommodate newer dopamine-based therapies or those that are developed in the future, but if alternative, non-dopamine therapies prove to be effective in the management of PD, this algorithm would need to be adapted. Further, whereas frequency of dosing (i.e., ≥ 5 doses per day) has now been identified as a clinical indicator of APD [3], we were not able to derive precise frequency of dosing from prescription claims, which do not have the clinical detail that is available in electronic medical records. Prescription claims also reflect filled prescriptions, and actual medication use may vary [3]. Our focus on a single year of data also means our findings on ambulatory assistive devices and specialty beds would reflect only those individuals who obtained a new piece of equipment during the study year. We would not capture individuals who may have been using devices obtained prior to the study period or those who may have been using assistive devices they obtained via other means, such as a loan program through a local senior center. As a result, our findings may underestimate the true prevalence of walker, wheelchair, and specialty bed use. In addition, our sample did not include individuals under 65 or those covered by Medicare Advantage plans, which provide Medicare Parts A, B, and D coverage together and were not included in our fee-for-service claims data source. Whereas claims data lack the richness of detail available through medical record review, studies using claims data allow for an efficient, relatively inexpensive, and faster way to study patterns of disease management across large samples.

We chose our algorithm threshold to maximize specificity at the expense of sensitivity, to ensure that the sample designated as advanced was most likely to have advanced disease. However, the current algorithm can be adapted based on the specific research question. For example, a study focused on detecting APD cases with dementia might opt to use a lower LED threshold to identify cases, or to add supplementary criteria such as requiring an additional medical claim for dementia or a pharmacy claim for dementia medication. Some studies might also benefit from examination of medication use over a longer period of time (e.g., 2 years), to enable detection of APD cases when an initial increase in dosage was later lowered due to clinical considerations.

Our findings represent an important step forward in the effort to identify and test a valid claims-based algorithm to identify patients with APD, which will facilitate population-level research such as comparative effectiveness, health care utilization, and economic burden studies. Future studies are needed to validate the algorithm in other datasets, against medical record data, and to further explore its sensitivity and specificity in identifying individuals with APD.

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CRediT authorship contribution statement

Nabilah Dahodwala:Conceptualization, Methodology, Formal analysis, Writing - original draft, Supervision, Project administration, Funding acquisition. Amy R. Pettit:Writing - review & editing, Visualization. Jordan Jahnke:Methodology, Software, Formal analysis, Data curation, Writing - review & editing. Pengxiang Li:Methodology, Software, Formal analysis, Writing - review & editing. Vrushabh P. Ladage:Writing - review & editing, Project administration. Prasanna L. Kundukuri:Writing - review & editing. Jorge Zamudio:Writing - review & editing. Yash J. Jalundhwala:Conceptualization, Resources, Writing - review & editing. Jalpa A. Doshi:Conceptualization, Methodology, Formal analysis, Resources, Writing - review & editing, Supervision, Funding acquisition.
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