Received: 29 October 2022 | Revised: 2 September 2023 | Accepted: 27 September 2023

DOI: 10.1002/hec.4766

RESEARCH ARTICLE

Health Economics WILEY

The effect of prescription drug insurance on the incidence of potentially inappropriate prescribing: Evidence from Medicare Part D

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Abstract

The Medicare Part D program has been documented to increase the affordability and accessibility of drugs and improve the quality of prescription drug use; however, less is known about the equity impact of the Part D program on potentially inappropriate prescribing—specifically, incidences of polypharmacy and potentially inappropriate medication (PIM) use based on different racial/ethnic groups. Using a difference in the regression discontinuity design, we found that among Whites, Part D was associated with increases in polypharmacy and "broadly defined" PIM use, while the use of "always avoid" PIM remained unchanged. Conversely, Blacks and Hispanics reported no changes in such drug utilization patterns.

KEYWORDS
Medicare Part D, polypharmacy, potentially inappropriate prescribing

JEL CLASSIFICATION
I13, I14, I18

1 | INTRODUCTION

Over one-quarter of health care spending in the United States (US) is attributable to inappropriate care, the provision of care in situations where evidence is lacking for benefit, and such care has been found to have a detrimental effect on the efficiency of health care system and harm to individual health (Berwick & Hackbarth, 2012; Brownlee et al., 2017; Delaune & Everett, 2008; Grady & Redberg, 2010). One of the most prevalent forms of inappropriate care, inappropriate prescribing among elderly adults, is a major public health concern in the US for several reasons. First, as nearly 90% of older adults in the US have consumed one or more prescription drugs, they are disproportionately susceptible to inappropriate prescribing (Martin et al., 2019). Second, while this population makes up 16% of the population, yet accounts for almost one third of total prescription drug spending, which is a primary source of health care expenditure of the country (U.S. Department of Health and Human Services, 2020; Mueller et al., 1997). Therefore, with an increased risk of adverse drug events, related morbidity, and mortality, the inappropriate prescribing in old adults would impose an extra cost on the US health care systems through additional, but preventable health care utilization (Page and Mark Ruscin, 2006).

Prescription drug insurance plays a pivotal role in reducing the financial burden of medication use. Due to an escalating proportion of out-of-pocket costs for prescription drugs in medical expenditure among old adults—many of whom experience multiple comorbidities—they tend to experience greater difficulties in securing stable access to prescribed medications (The

Henry J. Kaiser Family Foundation, 2003). To tackle the issue, the US federal government passed the Medicare Prescription Drug, Improvement, and Modernization Act of 2003 (P.L. 108–173) and introduced the Medicare outpatient drug coverage program (Part D) in 2006. This new program addressed some of the financial barriers, thereby benefiting the improvement of health conditions for Medicare beneficiaries. For example, the amount of out-of-pocket costs for drugs decreased substantially after the implementation of the program, although the total number of prescription drugs per patient increased (Liu et al., 2011; Yin et al., 2008). Furthermore, providing a greater level of access to drugs through insurance resulted in better health outcomes from both individual and community levels (Afendulis et al., 2011; Diebold, 2018). Despite these positive results, there still remain significant gaps in knowledge regarding the equity impact of Part D on inappropriate prescribing.

In this paper, we examine the impact of Medicare Part D on the incidence of potentially inappropriate prescribing using the Medical Expenditure Panel Survey (MEPS) and a difference in the regression discontinuity (D-RD) design. This approach is useful in estimating the effect of a single program of Medicare, such as Medicare Part D, because it does not require a key assumption behind the regression discontinuity (RD) design or difference-in-differences (DID) design, both of which were used to identify the causal effect of all Medicare programs in prior studies (Card et al., 2008; Dave & Kaestner, 2009). For example, the RD design and DID design assume continuity across every aspect affecting an outcome at age 65 except the enrollment of Medicare Part D or parallel trends in the outcome before and after age 65, respectively. However, these assumptions are unlikely to hold owing to the concurrent eligibility for other Medicare programs at age 65 and anticipatory effects of Medicare Part D enrollment (Alpert, 2016). Therefore, comparing the discontinuity at age 65 pre and post the implementation of Medicare Part D based on individuals' eligibility status on the program, the D-RD design can estimate the causal effect of Medicare Part D more efficiently than the RD and DID approaches (Asfaw, 2019; Booshehri & Dugan, 2021).

The two key measures of potentially inappropriate prescribing used in this study are polypharmacy and potentially inappropriate medication (PIM) use. We find that the implementation of Medicare Part D increased the probability of polypharmacy and PIM use among Whites; however, Blacks and Hispanics did not experience the increase of those outcomes. These results suggest that the effect of drug insurance coverage expansion on inappropriate prescribing could differ across racial/ethnic groups, depending on their level of coverage for prescription drugs when Medicare Part D was implemented.

The rest of the paper proceeds as follows: Section 2 provides background information on Medicare Part D, inappropriate prescribing, and variations in prescription drug use across different racial/ethnic groups. Section 3 describes the data. Section 4 discusses the identification strategies. Section 5 presents the results, along with several robustness checks and falsification tests. Section 6 discusses our findings. Section 7 concludes.

2 | BACKGROUND

2.1 | Medicare Part D

Medicare Part D, the voluntary prescription drug insurance coverage program for Medicare eligible beneficiaries, was implemented on January 1, 2006 as part of the Medicare Modernization Act (MMA) of 2003 (P.L. 108–173). Prior to the enactment of MMA, outpatient prescription drug coverage for persons aged 65 and above could be purchased from both private (e.g., Medicare health maintenance organizations and Medigap plans) and public (e.g., Medicaid plans and state assistance programs) sources. However, high copayment rates and limited terms contained within these existing programs posed serious out-of-pocket financial challenges for seniors. Particularly, their average annual out-of-pocket drug costs increased by 55% from $644 in 2000 to $996 in 2003. Moreover, 27% of the beneficiaries experienced a lack of access to prescription drug coverage in 2003 (The Henry J. Kaiser Family Foundation, 2003). The lack of outpatient prescription drug coverage was generally associated with negative health outcomes, such as hospitalization, and poorer physical/cognitive functioning (Kesselheim et al., 2014).

Medicare Part D increased the affordability and accessibility of medications among older Medicare eligible beneficiaries. With the standard benefit design established by Congress, individuals pay a $32 monthly premium and a $250 deductible with 25% coinsurance up to $2250 in total drug costs. After hitting an initial benefit threshold (the “donut hole”), however, they pay 100% of incurred drug costs up to $3600 where 5% of coinsurance rate is re-employed (Medicare Board of Trustees, 2014). This new prescription drug coverage program contributed to 18% reductions in out-of-pocket costs for prescription drugs among Medicare beneficiaries compared to 2005, and an increase of the percentage of the beneficiaries with any drug coverage up to 90% in 2006 (Hu et al., 2017; Lichtenberg & Sun, 2007). Additionally, in terms of an impact on health outcomes, the Part D program led to reduction of hospitalization rate as well as increased the likelihood of reporting good or better health among the beneficiaries (Afendulis et al., 2011; Diebold, 2018).

Medicare Part D has also been effective in improving the quality of prescription drug use, especially in terms of medication adherence (Lau et al., 2011). Medication adherence is an important quality measure in clinical care due to its significant association with adverse outcomes, such as hospitalization and nursing home admission (Bharucha MD et al., 2004; Schulz et al., 2011; Sokol et al., 2005). The evidence suggests that the implementation of Medicare Part D enhanced the medication adherence across various subgroups (Lau et al., 2011). In particular, Medicare eligible beneficiaries without prescription drug coverage or under Medigap plans benefited the most from transitioning to Part D (Safran et al., 2010). Moreover, most seniors enrolled in Medicare Part D with cardiovascular diseases and/or diabetes experienced improved adherence to medication therapies (Donohue et al., 2010; Gu et al., 2010; Zhang et al., 2010).

2.2 | Polypharmacy and potentially inappropriate medication use

Although researchers have documented the positive effects of the Part D program on out-of-pocket expenditures, patient morbidity, and adherence to medications, little is known about how Medicare Part D affects other important quality indicators, including polypharmacy and PIM use. Polypharmacy is most commonly defined as the use multiple of daily medications and a large body of literature used five or more medications as a threshold for polypharmacy (Masnoon et al., 2017). Although prescribing multiple medications is sometimes necessary and appropriate for geriatric patients with multiple chronic conditions, its consequences have been linked to negative health outcomes, such as falls, and physical and cognitive impairment (Maher et al., 2014). PIMs are defined as those medications whose potential risks outweigh their clinical benefits in seniors (Beers et al., 1991). The list of PIMs is based on the Beers criteria which has been updated by the American Geriatric Society. The use of PIMs is also associated with adverse drug reactions and events, and poorer health status (Jano & Aparasu, 2007). As a result, both polypharmacy and PIM use can lead to higher health care utilization and costs, putting a potentially significant burden on the US health care systems (Feng et al., 2019; Fu et al., 2007).

Medicare Part D may introduce opposite consequences regarding polypharmacy and PIM use among beneficiaries. One possible scenario is that moral hazard may arise because of the reduced out-of-pocket costs for prescription drugs, increasing the likelihood of polypharmacy and PIM use (Pauly, 2004). On the other hand, the frequency of polypharmacy and PIM use could be decreased through better access to a medication therapy management program offered by Part D plans (Smith & Clancy, 2006). Two studies assessed the short-term effect of Medicare Part D on PIM use, but their findings are inconclusive because one study showed no significant difference in PIM use between enrollees and non-enrollees of Part D, whereas the other found that the PIM use increased slightly among the enrollees, and also that in fact, the proportion of PIM use in total medication use reduced (Donohue et al., 2012; Fu et al., 2010). Furthermore, current evidence lacks the evaluation of impact of Medicare Part D on polypharmacy. Thus, with a longer period of post Medicare Part D, assessing both outcomes, polypharmacy and PIM use, together may increase our understanding of the long-term effect of prescription drug insurance on inappropriate prescribing.

2.3 | Variations in prescription drug use across racial/ethnic groups

To better identify the differential impacts of Part D across racial/ethnic groups with regard to the quality of prescription drug use, it is important to consider the moderating effects of social determinants of health—the societal and environmental conditions that shape overall health outcomes of individuals and communities (Braveman et al., 2011). These include factors such as socio-economics status, neighborhood and physical environment, social support, and access to health care (i.e., insurance coverage). Each factor interacts with the others, thereby reinforcing the existing structural disparities in health care utilization and outcomes experienced by disadvantaged populations, such as racial/ethnic minorities. For instance, with a higher proportion of low socio-economic status individuals, Blacks and Hispanics are more likely to suffer from a lack of insurance coverage compared to Whites (Kirby & Kaneda, 2010). Such coverage gaps may deteriorate the quality of medication treatment, reducing their opportunity of having a usual source of care and continuity of care, both of which are essential to establish a solid relationship between the patient and physician.

Blacks and Hispanics tend to experience poorer quality of medication treatment than Whites. The evidence suggests that Blacks have a lower chance of receiving not only the newer and more effective prescription drugs, but also simplified dosing regimens compared to Whites (Farley et al., 2006; Schauer et al., 2007; Wang et al., 2006, 2007). Furthermore, despite the same number of comorbidities, Blacks and Hispanics are prescribed fewer medications than their white counterparts (Briesacher et al., 2003; Cashion et al., 2015). These unequal patterns of prescription drug use are disadvantageous for the racial/ethnic

minorities, resulting in poor adherence and adverse drug events due to inappropriate medication use (Baehr et al., 2015; Gerber et al., 2010). The differences in prescription drug coverage across racial/ethnic groups may be attributable to these unfavorable circumstances for the minorities, given that the proportion of Blacks and Hispanics without any drug coverage tends to be higher than that of whites (McGarry, Strawderman, and Li, 2014).

2.4 | New contributions

Few studies have examined the potential impacts of Medicare Part D on racial/ethnic disparities, especially with respect to the quality of medication use (Hussein et al., 2016). While we do not explicitly measure disparities in this study, we aim to evaluate the equity impacts of Medicare Part D on polypharmacy and PIM use within different racial/ethnic groups. Both polypharmacy and PIM serve as proxies for the quality of prescription drug use. Our study is distinguished from the two prior studies on Medicare Part D and PIM use for several reasons (Donohue et al., 2012; Fu et al., 2010). First, we extend the post study period of Medicare Part D implementation from one or 2 years to 6 years to evaluate the long-term policy impact. Second, we attempt to capture varying effects of Medicare Part D on prescription drug use across racial/ethnic groups. Lastly, to estimate causal impacts of the policy more efficiently, we implemented D-RD design instead of DID design used in the other studies.

Focusing on the prescription drug insurance coverage as a primary source of disparities in the quality of medication use between racial/ethnic groups, we hypothesize that with increased coverage of prescription drug insurance, individuals would have a lower out-of-pocket cost for medications, thereby increasing their demand for prescription drugs. This change may increase the likelihood of polypharmacy and PIM use, especially among those at the margin of polypharmacy (i.e., the demand side mechanism). Second, improved access to prescription drugs via prescription drug insurance coverage would enhance the patient-physician relationship by addressing cost-related medication non-adherence (Jackson et al., 2004). This may ensure the continuity of care, reducing the likelihood of polypharmacy and PIM use among newly insured individuals with Medicare Part D through better awareness of their prescription records by health care providers (i.e., the supply side mechanism).

Considering that increased drug insurance coverage under Medicare Part D led to greater utilization of both essential and non-essential medications, including PIM (Polinski et al., 2011), it is important to understand the role of demand and supply side mechanisms on inappropriate drug prescribing, especially based on individuals' initial drug insurance coverage status. Given the discrepancy of insurance coverage for prescription drugs between whites and Blacks/Hispanics prior to 2006 (Figure 1), we presume that the dynamic between the demand and supply side mechanism is heterogeneous across racial/ethnic groups in that the former is more dominant than the other among Whites, and vice versa among Blacks/Hispanics.

3 | DATA

The data source for this study is the MEPS for 2001–2012. The MEPS provides detailed information on health care utilization and expenditures from nationally representative samples of the US non-institutionalized population. Using a 2-year overlapping panel design (i.e., for any particular year, the sample consists of individuals in their first year of the panel and those in their second year of the panel), the dataset collects five rounds of a household interview over two calendar years for each panel. We use the Full-Year Consolidated Data files and Prescribed Medicines files in our analysis. The Full-Year Consolidated Data file contains demographic and socioeconomic characteristics of individuals and households, as well as their records of health insurance and expenditures. The Prescribed Medicines file provides full details of each prescription drug, including drug name and code, therapeutic class, and quantity dispensed. We restricted the study population to individuals aged between 60 and 69 from the three racial/ethnic groups, including Whites, Blacks, and Hispanics.

3.1 | Definition of polypharmacy and potentially inappropriate medication use

To identify a respondent's status for polypharmacy, we used round and therapeutic classification variables in the Prescribed Medicines files. Specifically, we define polypharmacy as the condition of filling five or more unique classification of drugs at a single round. This definition of polypharmacy is the approach most commonly used in geriatric population (Masnoon et al., 2017). Individuals with at least one episode of polypharmacy during the year are labeled as polyphar-

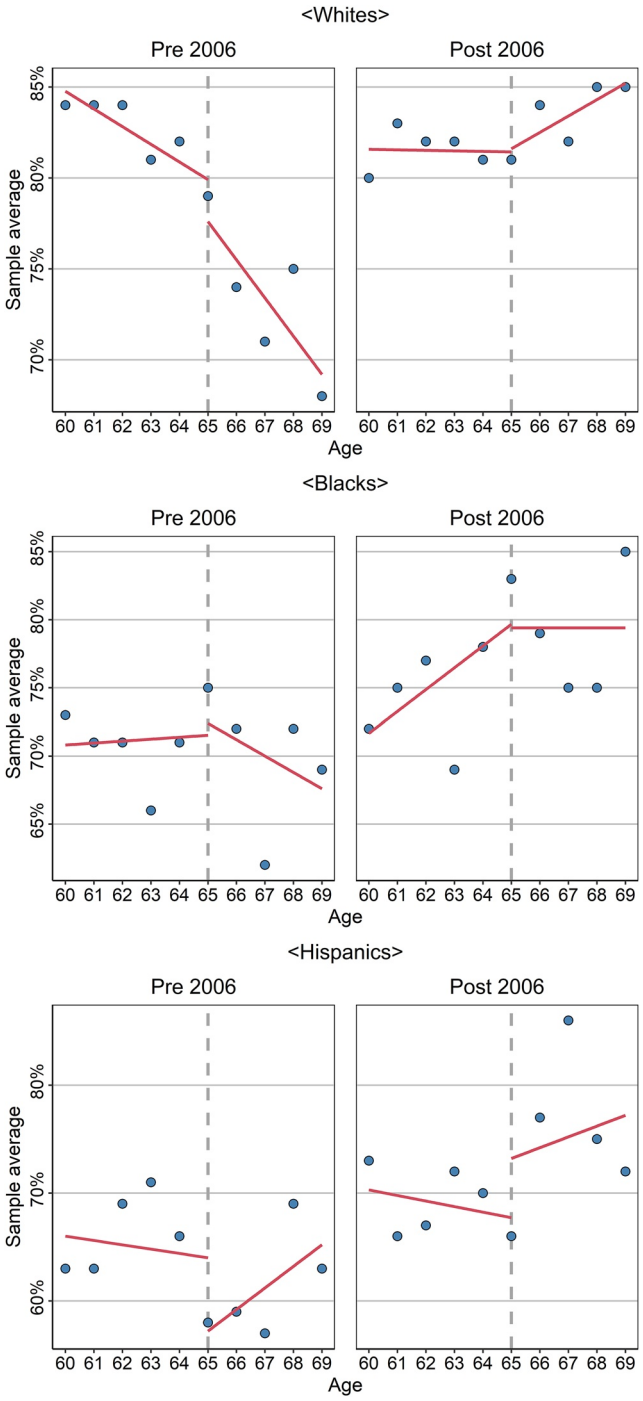

FIGURE 1 Discontinuity in prescription drug coverage at age 65 before and after the implementation of Medicare Part D by racial/ethnic groups. [Colour figure can be viewed at wileyonlinelibrary.com]

macy users. For therapeutic classification of drugs, we adopted the Multum Lexicon (ML) therapeutic classification system, which provides a three-level nested category of each drug. In addition, we classified prescription drugs according to the 2012 update of the Beers criteria to determine the use of PIM among individuals following the approach suggested by Davidoff et al. (2015).[1] Those who filled at least one prescription listed on the 2012 Beers criteria during the year are defined as PIM users. When profiling the PIMs, the ML therapeutic classification system was also utilized. It is worth noting that the 2012 Beers criteria provides the most comprehensive list of PIMs for the study period (i.e., from 2001 to 2012), thereby allowing us to incorporate new medications not listed in the previous (2003) version (Fick et al., 2003). This may imply that PIM incidence identified in this study do not always reflect a lack of quality in prescribing behaviors among physicians, given that Medicare Part D had been implemented in 2006 before the 2012 Beers criteria was published. To address the most up-to-date evidence during the study period, however, we use the 2012 Beers criteria despite this limitation.

4 | IDENTIFICATION

This section demonstrates an empirical framework determining the local average treatment effect of Medicare Part D in the study. We pursue the D-RD design that compares the discontinuity in the predicted probabilities of polypharmacy and PIM prescription among individuals below age 65 (i.e., the control group) to the corresponding probabilities among those aged 65 and above (i.e., the treatment group), before and after the implementation of Medicare Part D.

The rationale of using the D-RD design is to overcome a limitation of conventional RD design. In particular, since all parts of Medicare—Part A, B, C, and D—become eligible at age 65, differentiating the effect of Medicare Part D from other Medicare programs is impossible with the conventional RD design that compares the discontinuity around age 65. However, exploiting the fact that only Medicare Part D was introduced in 2006, the effects of Medicare Part A, B, and C would be offset if using the D-RD design. With this approach, we can determine the causal effect of Medicare Part D on polypharmacy and PIM prescription, examining the differences in discontinuities around age 65 before and after 2006 (Asfaw, 2019; Booshehri & Dugan, 2021).

The D-RD model takes the following form:

$$\begin{aligned}\text{Prob (Polypharmacy or PIM)} = g^{-1}(&\alpha + \beta_1 \times 1(\text{Age} \geq 65)_{irt} + \beta_2 \times 1(\text{Year} \geq 2006)_{irt} \\ &+ \beta_3 \times 1(\text{Age} \geq 65)_{irt} \times 1(\text{Year} \geq 2006)_{irt} \\ &+ \beta_4 f(\text{age}_{irt})\left[1 + (\text{Age} \geq 65)_{irt}\right] + \boldsymbol{X}_{irt}\boldsymbol{\delta} + \gamma_r + \pi_t\big)\end{aligned} \tag{1}$$

where Pr (Polypharmacy or PIM) is the population average probability of polypharmacy or PIM prescription. g^{-1} is the inverse of logit link function. $1(\text{Age} \geq 65)_{irt}$ is an indicator for whether the individual i is aged 65 or older and $1(\text{Year} \geq 2006)_{irt}$ is an indicator for whether the prescription was claimed after the implementation of Medicare Part D. $f(\text{age}_{irt})$ is a quadratic function of age, interacting with the indicator of age 65 and older to incorporate the change of prescription patterns due to aging. $\boldsymbol{X}_{irt}$ is a vector of individual level demographic characteristics, including sex, race/ethnicity, marital status, smoking status, education level, and household income. Census region (γ_r) and year of survey (π_t) fixed effects are also included in the model. The primary variable of interest is the interaction between the age and year indicators, $1(\text{Age} \geq 65)_{irt} \times 1(\text{Year} \geq 2006)_{irt}$. The coefficient of the interaction term, β_3, is interpreted as the difference in the population average probability of polypharmacy or PIM use before and after the implementation of Medicare Part D, thus identifying the causal effect of the policy implementation. Survey weights from the MEPS are addressed in the model.

Additionally, we applied a negative binomial (NB) regression model that characterizes the effect of Medicare Part D on the number of prescriptions for polypharmacy or PIM (Greene, 2008).

$$E(y_i|\boldsymbol{X}_i, \varepsilon_i) = \exp(\alpha + \boldsymbol{X}_i\boldsymbol{\beta} + \varepsilon_i) \tag{2}$$

where $\boldsymbol{X}_i$ is a vector of age and year indicator variables, their interaction term, individual level demographic characteristics, fixed effects of census region and survey year.

We generated variables indicating the number of different classification of drugs, and numbers in the variable were truncated at five in the case of polypharmacy. In the NB model, the coefficient of the same interaction term as above is interpreted as the difference in the predicted number of prescriptions or PIM before and after the implementation of Medicare Part D. This model also adjusted survey weights from the MEPS.

Lastly, we conducted a sensitivity analysis by limiting the outcome of PIM use to medications classified as "no exception to use" in the Beers criteria. In their analysis of PIM prevalence among community-dwelling older adults, Davidoff et al. (2015) observed that a certain proportion of PIM use demonstrated clinical justification based on the duration of prescription and specific medical conditions. Notably, the prevalence decreased by 12% points, from 42% to 30%, by refining the operational definition of PIM use from a "broad" to "qualified" definition. Accordingly, we narrowed down the definition of PIM to include only "always avoid" medications in the Beers criteria—the number of PIM categories decreased from 38 to 26. This adjustment may help alleviate the limitations associated with measuring PIM use as a marker of inappropriate prescribing because the metric in our primary analysis only reflects potential misuse of medications. To further understand the within group effects of Medicare Part D across racial/ethnic groups, we established three independent datasets from the pooled sample, each of which represents a single racial/ethnic group, including Whites, Blacks, and Hispanics. On each dataset, we implemented the same identification strategies from both models without the race/ethnicity covariate. Likewise, the coefficient of the interaction term shows the effect of Medicare Part D on polypharmacy or PIM for respective racial/ethnic groups.

5 | RESULTS

5.1 | Descriptive statistics

Table 1 shows demographic and socioeconomic characteristics of the study population, as well as their health status, such as physical/cognitive limitation and comorbidity condition. The total study population consists of 23,330 respondents, representing 20 million population-weighted individuals nationwide. The mean age is 64 years. Female comprises 52% among the sample. The proportion of Whites, Blacks, and Hispanics is 84%, 10%, and 7%, respectively. About 94% of the sample finished at least high school. The distribution of income level measured by poverty status shows that about 80% are under the category of middle or high income. Among all respondents, 26% experience physical limitation, and the number decreases to 6% in terms of cognitive limitation. We also present summary characteristics of outcomes by the groups based on the year of policy implementation (pre/post 2006), age (<65), and race/ethnicity in Table A1.

5.2 | Effects on polypharmacy and PIM use

Table 2 presents the effect of Medicare Part D on polypharmacy. The estimates in the odd columns indicate the change in the population average probability of polypharmacy due to Medicare Part D, while the estimates in the even columns show

TABLE 1 Summary characteristics (unit: %).

Characteristics	Pooled sample (2001–2012)	Pre 2006	Post 2006
Sample size (*n*)	23,330	9572	13,758
Weighted population (*n*)	20,484,742	7,786,688	12,698,054
Age ($M \pm$ SD)	64.31 ± 2.88	64.36 ± 2.89	64.28 ± 2.87
Female	52.44	52.48	52.42
Race			
White	83.74	83.76	83.73
Black	9.53	9.7	9.42
Hispanic	6.73	6.54	6.84
Education			
Less than high school	6.03	7.51	5.12
High school diploma	41.56	47.67	37.81
College or postgraduate	52.42	44.82	57.08
Income level (poverty status)			
Negative or poor (<100%)	7	7.28	6.84
Near poor (<125%)	3.41	3.5	3.36
Low income (<200%)	10.48	11.6	9.79
Middle income (<400%)	27.05	28	26.47
High income (≥400%)	52.06	49.63	53.55
Married	68.9	68.81	68.95
Urban residence	80.24	78.85	81.1
Region			
Northeast	19.94	19.78	20.04
Midwest	23.03	24.18	22.32
South	37.46	36.92	37.79
West	19.57	19.12	19.85
Smoker	14.36	15.99	13.35
Physical limitation	25.44	25.68	25.29
Cognitive limitation	6.3	6.45	6.22

TABLE 2 The effect of Medicare Part D on polypharmacy.

	All		White		Black		Hispanic	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Polypharmacy	Number of prescriptions (5 or more)	Polypharmacy	Number of prescriptions (5 or more)	Polypharmacy	Number of prescriptions (5 or more)	Polypharmacy	Number of prescriptions (5 or more)
Age 65 × year 2006	0.038**	0.047	0.036*	0.052	0.071	0.133	0.021	−0.180
	(0.019)	(0.065)	(0.021)	(0.078)	(0.047)	(0.145)	(0.054)	(0.135)
Number of prescriptions (mean, 60–64 years)	-	3.22	-	3.23	-	3.32	-	3.08
N	23,330	23,330	16,442	16,442	3802	3802	3086	3086

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

the change in the total number of prescriptions (5 or more) before and after Medicare Part D. Columns (1) and (2), estimates from the pooled sample, demonstrate that the probability of polypharmacy increased by 3.9% points at the significance level of 5%, and that change in the number of prescriptions was not statistically significant, respectively. Columns (3) through (8) show the effects of Medicare Part D on polypharmacy according to the racial/ethnic groups. Column (3) indicates that Whites experienced an increase in the probability of polypharmacy by 3.8% points at the significance level of 10%. Among Blacks and Hispanics, however, the introduction of Part D did not change their likelihood of experiencing polypharmacy nor the number of prescriptions. The average number of prescriptions among persons aged 60–64 years is 3.2 and does not vary across the racial/ethnic groups.

Table 3 illustrates the effect of Medicare Part D on PIM use. The estimates in the odd columns present the change in the population average probability of PIM use as a result of Medicare Part D, whereas the estimates in the even columns indicate the change in the total number of PIM use (1 or more) before and after Medicare Part D. Column (1) shows that the probability of PIM use increased by 5.7% points at the significance level of 1%. Also, Column (2) shows that Medicare Part D increased the number of PIM use as much as 0.08 at the 1% level of significance. The remaining columns show the effects of Medicare Part D on PIM use according to the racial/ethnic groups. Column (3) presents that among Whites, the probability of PIM use increased by 6.0% points at the significance level of 1%. Column (4) demonstrates that the number of PIM use increased by 0.09 at the 1% level of significance. As compared with the results in polypharmacy among Blacks and Hispanics, the introduction of Medicare Part D did not affect their patterns of PIM use as well. The average number of PIM use among people between 60 and 64 years is 0.35, which is similar across the racial/ethnic groups (Table 4).

Table 4 shows the results of a sensitivity analysis that restricted the list of PIMs to only include "always avoid" medications in the Beers criteria. None of the estimates demonstrated statistical significance, suggesting that the introduction of Medicare Part D had no impact on the utilization of "always avoid" PIMs across racial/ethnic groups. Additionally, we observed a notable decrease in the magnitude of estimates among Whites from 6.1 to 0.8% points, placing them behind Blacks (2.8% points) and Hispanics (1.7% points) in terms of the magnitude.

5.3 | Effects on the schedule of prescription drugs across racial/ethnic groups

To better understand the underlying mechanism of our primary findings—that the introduction of Medicare Part D increased the probability of polypharmacy and PIM use among Whites only—we also analyzed the change in the rank and proportion of frequently prescribed drugs among Whites by comparing those before and after the policy introduction. Table 5 shows the list of top 15 prescribed drugs among Whites after 2006 and their matched rank and proportion prior to 2006. The results indicate that no notable differences in the combination of top 15 drugs between before and after Medicare Part D were identified except the one drug, HMG-CoA reductase inhibitors. This drug ranked 2nd (4%) after Medicare Part D, whereas it initially placed 28th (1%) before Medicare Part D. Moreover, the medication schedule among Blacks and Hispanics also presented a similar pattern observed among Whites. For example, there was a noteworthy increase in the prescription of HMG-CoA reductase inhibitors following the implementation of Medicare Part D, as demonstrated in Tables 6 and 7. However, an additional surge in the prescription of antidiabetic drugs, especially biguanides and sulfonylureas, was observed among Blacks and Hispanics

TABLE 3 The effect of Medicare Part D on PIM use.

	All		White		Black		Hispanic	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PIM	Number of PIM (1 or more)	PIM	Number of PIM (1 or more)	PIM	Number of PIM (1 or more)	PIM	Number of PIM (1 or more)
Age 65 × year 2006	0.059***	0.083***	0.061***	0.093***	0.056	0.037	0.027	0.025
	(0.016)	(0.023)	(0.018)	(0.026)	(0.041)	(0.054)	(0.038)	(0.054)
Number of PIM (mean, 60–64 years)	-	0.35	-	0.35	-	0.34	-	0.31
N	23,330	23,330	16,442	16,442	3802	3802	3086	3086

Abbreviation: PIM, potentially inappropriate medication.

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

TABLE 4 The effect of Medicare Part D on PIM use classified as no exception under Beers criteria.

	All	White	Black	Hispanic
	(1)	(2)	(3)	(4)
	PIM	PIM	PIM	PIM
Age 65 × year 2006	0.010	0.008	0.028	0.017
	(0.011)	(0.012)	(0.025)	(0.029)
N	23,330	16,442	3802	3086

Abbreviation: PIM, potentially inappropriate medication.

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

TABLE 5 The list of top 10 prescribed drugs among Whites before and after Medicare Part D.

	Post 2006		Pre 2006	
Drug category	Rank	Proportion	Rank	Proportion
HMG-CoA reductase inhibitors	1	0.075	24	0.013
Cardioselective beta blockers	2	0.044	2	0.041
Angiotensin converting enzyme inhibitors	3	0.043	3	0.041
Proton pump inhibitors	4	0.034	5	0.03
Thyroid hormones	5	0.029	6	0.027
Antihypertensive combinations	6	0.029	8	0.025
Narcotic analgesic combinations	7	0.026	7	0.025
Calcium channel blocking agents	8	0.022	4	0.033
SSRI antidepressants	9	0.021	15	0.018
Thiazide and thiazide-like diuretics	10	0.02	12	0.02

Abbreviation: SSRI, selective serotonin reuptake inhibitor.

TABLE 6 The list of top 10 prescribed drugs among Blacks before and after Medicare Part D.

	Post 2006		Pre 2006	
Drug category	Rank	Proportion	Rank	Proportion
HMG-CoA reductase inhibitors	1	0.069	21	0.013
Antihypertensive combinations	2	0.046	4	0.038
Angiotensin converting enzyme inhibitors	3	0.045	2	0.051
Calcium channel blocking agents	4	0.045	1	0.056
Cardioselective beta blockers	5	0.04	5	0.035
Narcotic analgesic combinations	6	0.029	10	0.024
Proton pump inhibitors	7	0.028	11	0.024
Thiazide and thiazide-like diuretics	8	0.026	7	0.033
Nonsteroidal anti-inflammatory agents	9	0.025	9	0.025
Biguanides	10	0.025	64	0.004

only. The lists of top 10 PIMs before and after Medicare Part D among Whites, Blacks, and Hispanics were also presented in Tables A2–A4, respectively, in Appendix A1.

5.4 | Robustness check and falsification tests

The results demonstrate that the implementation of Medicare Part D increased the likelihood of polypharmacy and PIM use among Whites but did not yield any changes in both outcomes among Blacks and Hispanics. In this section, we examine several alternative explanations and falsification tests to check the robustness of the main findings.

5.4.1 | Assumptions of D-RD

The validity of D-RD identification method relies on the assumption that the distribution of covariates within each group is independent to treatment exposure. To examine the time-invariant characteristics of covariates, we replaced the dependent variable with the covariates in the Equation (1). The results of D-RD analysis on the covariates are presented in Table A5. From Panel A and B, no statistically significant effect was identified except for two variables indicating high school or college graduates. From Panel C, four variables, such as sex, marital status, and education level, were statistically significant. From Panel D, three variables, including smoking status and income level, were statistically significant. Additionally, we evaluated the effects of reducing or increasing the age bandwidth on the D-RD estimates using the main model. Table A6 shows the results by two different age bandwidths: Age of 59–70 and 61–68. When increasing the age bandwidth, the effect size for polypharmacy and PIM use becomes larger in the pooled sample and Whites only sample. When decreasing the bandwidth, however, the effect on the probability of polypharmacy becomes statistically insignificant in both samples.

TABLE 7 The list of top 10 prescribed drugs among Hispanics before and after Medicare Part D.

	Post 2006		Pre 2006	
Drug category	**Rank**	**Proportion**	**Rank**	**Proportion**
HMG-CoA reductase inhibitors	1	0.071	23	0.013
Angiotensin converting enzyme inhibitors	2	0.053	1	0.049
Cardioselective beta blockers	3	0.04	4	0.037
Proton pump inhibitors	4	0.036	5	0.033
Biguanides	5	0.032	59	0.005
Nonsteroidal anti-inflammatory agents	6	0.03	6	0.031
Antihypertensive combinations	7	0.029	10	0.023
Calcium channel blocking agents	8	0.028	3	0.038
Sulfonylureas	9	0.025	58	0.005
Narcotic analgesic combinations	10	0.024	12	0.021

5.4.2 | Difference-in-difference

We employed another empirical estimation strategy, the difference-in-difference (DID) approach, to test the robustness of the findings. We excluded samples aged 65 years old from the analysis to minimize misclassification bias. Figure A1 illustrates that the assumption of a parallel trend between the control (i.e., 60–64) and treatment (i.e., 66–69) groups holds before the introduction of Medicare Part D in our analysis. The results from the DID analysis (Table A7) support the primary findings; specifically, the implementation of Medicare Part D increased the probability of polypharmacy and PIM use by 3.9% and 4.6%, respectively, among Whites, however, Blacks and Hispanics did not show any changes in both outcomes.

5.4.3 | Anticipatory and drug discount cards effects

The introduction of Medicare Part D could change drug utilization patterns of the beneficiaries. With anticipated benefits from this new program, the samples from 2004 to 2005 may show a different pattern of drug utilization compared to those observed prior to the enactment (2003) and after the implementation of Medicare Part D (2006). The evidence supports this claim in that drug utilization of the seniors was temporarily decreased in 2004 and 2005, reflecting their expectation of reducing future drug costs (Alpert, 2016). In contrast, there is the evidence suggesting that drug utilization between 2004 and 2005 increased in some groups due to the implementation of the Prescription Drug Discount Card and Transitional Assistance Program, which was introduced to lift a burden of high drug cost for low-income Medicare beneficiaries until Medicare Part D was fully implemented (Huh & Reif, 2017). Thus, to eliminate potential bias derived from anticipatory and the drug discount card effects on the D-RD estimates, we excluded samples from 2004 to 2005 before conducting the analysis based on the Equation (1). Table

A8 presents the results. The estimates of polypharmacy from the pooled sample and Whites only sample became statistically insignificant, while maintaining statistical significance in the PIM use. Also, from Blacks only sample, we observed that the implementation of Medicare Part D is associated with the increase in the probability of polypharmacy by 11% point at the significance level of 5%.

5.4.4 | Falsification tests

To ensure a causal relationship between Medicare Part D and the prescription of polypharmacy and PIM, we also performed two falsification tests by varying the age of Medicare eligibility as well as the year of implementation, respectively. If the coefficients of the interaction term from the tests yield equivalent results to the primary analysis, our findings in this study may rely on random chance. Tables A9 and A10 present the results from the falsification tests. The effect of varying age eligibility of Medicare Part D between 62 and 68 years old does not affect the prior trend of increasing PIM use in the pooled sample and Whites only sample (Table A9). However, when setting the age eligibility to 62 and 63 years old, the effect of Medicare Part D on polypharmacy became statistically insignificant in both samples. Moreover, at the eligibility of 68 years old, the effect of Medicare Part D on polypharmacy became statistically significant among Blacks. When varying implementation year of Medicare Part D between 2002 and 2005, we did not find statistically significant results in polypharmacy and PIM use except the case that the effect of Medicare Part D on polypharmacy and PIM use became statistically significant among Blacks if the implementation year set to 2005. Please note that the similar results observed between the primary analysis and falsification test in Table A9, especially in Panels C and D, may raise concerns that the findings from the primary analysis could be a result of random chance. However, this is unlikely given a significant increase of prescription insurance coverage among Whites aged 67 and 68 before and after the implementation of the policy in 2006, as illustrated in Figure 1. Additionally, the absence of statistically significant findings from the second falsification test, which varied the year of policy implementation, confirms that our primary analysis effectively captured the impact of Medicare Part D on polypharmacy and PIM use, rather than relying on random chance.

6 | DISCUSSION

The overall results of the analysis suggest that among Whites, the implementation of Medicare Part D increased the likelihood of polypharmacy and "broadly defined" PIM use, but did not escalate the likelihood of prescribing "always avoid" PIMs. Moreover, this policy introduction led to an increase in the number of PIM prescriptions, while the number of prescriptions exceeding the threshold for polypharmacy (i.e., five or more) remained unchanged. Among Blacks and Hispanics, we did not observe any change in the likelihood of polypharmacy and both types of PIM use, as well as the numbers of prescriptions and PIM use. These may imply that introduction of Medicare Part D had a negative impact on the quality of medication use among Whites and that Blacks and Hispanics benefited from improved financial access to medications without any increase in consumption that could potentially compromise the quality of their medication treatment.

However, it is essential to emphasize that implications mentioned above can be challenged by considering the outcomes of both sensitivity analysis and the analysis of prescription schedules, because evidence from these analyses offer an alternative explanation. Our sensitivity analysis, which mitigated uncertainties in identifying inappropriate prescribing based on claims-based measures, revealed that the introduction of Medicare Part D did not affect the likelihood of "always avoid" PIM prescriptions among different racial/ethnic groups. Notably, Whites exhibited the lowest likelihood of prescribing "always avoid" PIMs after Medicare Part D compared to Blacks and Hispanics. In addition, the analysis of prescription schedules among Whites showed that their proportion of statin prescriptions (i.e., HMG-CoA reductase inhibitors) increased after the implementation of Medicare Part D. Thus, these additional findings as well as the evidence of increased polypharmacy rates among Whites may end up leading us to divergent conclusions.

Here we present alternative explanations for our findings. First, the evidence of increased polypharmacy and "broadly defined" PIM use among Whites may not necessarily indicate a negative impact of Medicare Part D on the quality of their medication use. Specifically, considering that older adults tend to experience multiple chronic conditions, many of which require a large number of prescriptions (e.g., atherosclerotic vascular disease) (Nobili et al., 2011), the higher likelihood of polypharmacy (i.e., being prescribed five or more medications) may actually suggest enhanced access to necessary medicines. Furthermore, the lower probability of prescribing "always avoid" PIM and statistically non-significant relationship between Medicare Part D and "always avoid" PIM use among Whites confirm that the introduction of this policy did not have a negative

effect on the quality of medication use. Second, the finding that Blacks and Hispanics did not experience an increase in polypharmacy after the introduction of Medicare Part D implies that these groups may still face challenges in accessing necessary medications compared to Whites. This disparity could be attributed to initial disparities in prescription drug coverage levels, as depicted in Figure 1. It is likely that the implementation of the policy did not completely bridge the gap, resulting in their access to medication remaining lower in comparison to Whites. Third, Medicare Part D may have played a crucial role in facilitating the prescription of statins, which have been reported to be underutilized among older adults (Ngo-Metzger et al., 2019). Notably, our findings indicate that all racial/ethnic groups, including White, Blacks and Hispanics, experienced a remarkable increase in statin prescriptions following the implementation of Medicare Part D.

However, caution should be exercised when interpreting the evidence that could imply differentially improved access to underused medications across different racial/ethnic groups, as an indicator of persistent racial/ethnic disparities in medication access. This caution is necessary because our study design was not specifically intended to evaluate the impact of increased prescription drug coverage on the extent of access to underused medications across racial/ethnic groups. Therefore, future research needs to prioritize examining this unanswered topic.

There are several potential limitations to the results. First, the null findings of the subgroup analysis could indicate that there was insufficient statistical power due to small sample size. However, null findings due to insufficient sample size is unlikely for this study since our racial/ethnic subgroup analysis focuses on the largest subgroups, with thousands of observations available before statistical weighting for White non-Hispanics ($N = 16{,}442$), Black non-Hispanics ($N = 3802$), and Hispanics ($N = 3086$). Second, it may be the case that an alternative causal inference strategy (e.g., triple difference design) could have been used to identify the effects of the Part D. However, since our identification approach relies on using a difference in outcomes across time (before/after introduction of Part D) and difference in outcomes across treatment groups (before/after age 65), a D-RD model is best suited to use both sources of variation to estimate the average treatment effects of the Part D program. Furthermore, the use of a triple difference model would require identifying a third source of between group variation, of which is not identified in our model (Olden & Møen, 2022). Lastly, this study employed multiple outcome measures, including polypharmacy and both the "broadly defined" and "always avoid" PIM use, to identify incidences of potentially inappropriate prescription. However, our ability to assess actual inappropriate prescription remains constrained by the absence of evidence from "not always avoid" PIMs. Thus, we recommend that future studies based on claims-based measures implement a more refined categorization of PIMs to mitigate this limitation.

To address inappropriate medication prescribing in the US, it is imperative to examine how different health care systems are actively responding to this challenge. The National Health Service (NHS) of the United Kingdom provides free access to non-emergency medical services through general practitioners (GPs). Hence, GPs have a significant role in avoiding polypharmacy and PIM use among their patients. For example, if the patient utilized medical services from a hospital, GPs would be also informed about their treatments and prescriptions through coordination with other providers, thereby ensuring the prevention of the inappropriate drug prescribing (Shaw et al., 2011). South Korea adopted a different approach tackling this problem using information and communication technology (ICT). Considering that South Korea allows patients to utilize medical services from a hospital freely without a referral from a primary care physician, the risk of polypharmacy and PIM use could be potentially high in this country. However, with the advancement of ICT of the country as well as the benefit of a single payer system, South Korea successfully introduced a nationwide drug utilization review (DUR) system in 2010, which prevents inappropriate medication prescribing by showing an alarming signal to providers if their prescribed drugs cause potential harm to a patient (Yang et al., 2015).

Lessons from the two countries on health system-level response to inappropriate medication prescribing may provide significant policy implications to the US health care system. Given that operating principles of Medicare Advantage (MA) plans are similar to those of NHS in light of setting the role of primary care physician as a gatekeeper, the MA plans could reduce the likelihood of inappropriate prescribing by improving a degree of coordination among providers within the same plan. For example, if the primary care physicians are better equipped with shared information on treatments and prescriptions of their patients, they can identify a potential risk of inappropriate prescribing in advance. Also, considering the capacity of ICT of the US, Medicare and MA plans should consider further investment on developing the DUR system detecting prescriptions of inappropriate medication on a real-time basis. In so doing, they would receive benefit from reducing cost by avoiding the incidence of adverse outcomes among enrollees, and this benefit would end up exceeding the expense on developing the DUR system.

7 | CONCLUSIONS

The findings of this study shed light on the differential effects of Medicare Part D on the quality of medication use across racial/ethnic groups. Among Whites, the introduction of this policy was associated with a higher likelihood of polypharmacy and "broadly defined" PIM use. However, there was no significant impact on the use of "always avoid" PIM. In contrast, among Blacks and Hispanics, both polypharmacy and PIM use remained unchanged following the policy implementation. However, it is important to acknowledge that considering the utilization of claims-based measures in this study, our capability to judge the actual inappropriateness of the increases in such drug usage among Whites remains limited.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available from Medical Expenditure Panel Survey at https://meps.ahrq.gov/mepsweb/.

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ENDNOTE

[1] Davidoff et al. (2015) implemented two different types of operational definitions, a "broad" and "qualified" definition, to identify PIM in MEPS. In this study, we specified the PIM use based on the "broad" definition.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Lee, D., Kim, S., & Dugan, J. A. (2024). The effect of prescription drug insurance on the incidence of potentially inappropriate prescribing: Evidence from Medicare Part D. *Health Economics*, *33*(1), 137–152. https://doi.org/10.1002/hec.4766