Published in final edited form as:

J Med Econ. 2016 August ; 19(8): 806–811. doi:10.1080/13696998.2016.1176031.

Identifying Patients with Cost-related Medication Non-adherence: A Big-Data Approach

James X. Zhang, PhD, MS and David O. Meltzer, MD, PhD

From the Section of Hospital Medicine, Department of Medicine (J.X.Z., D.O.M.); Department of Economics (D.O.M.); and the Irving B. Harris School of Public Policy Studies (D.O.M.); The University of Chicago

Abstract

Background—Millions of Americans encounter access barriers to medication due to cost. However, to date, there is no effective screening tool that identifies patients at risk of cost-related medication non-adherence (CRN).

Objective—By utilizing a big-data approach to combining the survey data and electronic health records (EHRs), we aimed to develop a method of identifying patients at risk of CRN.

Design, Participants, and Main Measures—CRN data were collected by surveying patients about CRN behaviors in the past three months. By matching the dates of patients' receipt of monthly Social Security (SS) payments and the dates of prescription orders for 559 Medicare beneficiaries who were primary SS claimants at high risk of hospitalization in an urban academic medical center, we identified patients who ordered their outpatient prescription within two days of receipt of monthly SS payments in 2014. We assessed the predictive power of this information on CRN, using multivariate logistic regression analysis.

Results—Among the 559 Medicare patients at high risk of hospitalization, 137 (25%) reported CRN. Among those with CRN, 96 (70%) had ordered prescriptions on receipt of SS payments one or more times in 2014. The area under Receiver Operating Curve was 0.70 using the predictive model in multivariate logistic regression analysis.

Conclusion—With a new approach to combining the survey data and EHR data, patients' behavior in delaying filling of prescription until funds from SS checks become available can be measured, providing some predictive value for cost-related medication non-adherence. The big-data approach is a valuable tool to identify patients at risk of CRN and can be further expanded to the general population and subpopulations, providing a meaningful risk-stratification for CRN and facilitating physician-patient communication to reduce CRN.

Introduction

Despite the establishment of Medicare Part D, the cost of prescription drugs remains a barrier to accessing effective medical treatment for many older Americans¹. Over one-third

Address correspondence and reprint requests to James X. Zhang, PhD, MS, Section of Hospital Medicine, Department of Medicine, 5841 S. Maryland Ave., MC 5000, Chicago, IL, 60637. xzhang1@medicine.bsd.uchicago.edu.

There are no conflicts of interest.

of older patients report cost-related medication non-adherence (CRN), adversely affecting patient outcomes and subsequently raising health care costs^{2,3,4,5}. Several risk factors, including lack of insurance coverage, high out-of-pocket payments, and high disease burden in both general health and mental health for CRN, have been identified^{6,7,8,9,10,11}. There is no known low-cost, effective tool to screen and identify patients with CRN. Neither copays nor income alone accurately predicts non-adherence and these measures do not have the sensitivity or specificity to identify CRN. Worse still, this information is not usually available to healthcare providers. Common measures of non-adherence (e.g., medication possession ratio, gaps in filling of prescriptions^{12,13,14}) are not specific to non-adherence related to financial costs and thus suffer from low sensitivity and specificity because of other factors such as cultural preferences and side effects that are correlated with non-adherence. Universal approaches in which all patients are asked about the financial burdens of medications and CRN are costly and unlikely to be followed by providers.

We propose a big-data approach to screen patients at the risk of CRN. This “big-data” approach requires the combinations of several dimensions of data rather than one single data source, including survey data, electronic health record (EHR), and publicly available administrative information from the Social Security Administration. This method, if implemented at the population-level, can effectively reduce the time-consuming burden of surveying individual patients and provide a meaningful risk-stratification tool for CRN. It can thus help facilitate physician-patient communication regarding CRN behavior and hopefully initiate possible interventions to reduce CRN. Such interventions can include changing the tier of medication prescribed, using generic substitutions, or waiving out-of-pocket payments in part or in entirety based on patients’ income.

Methods

Exploring value of timing when economic resources becomes available

There is no known tool to identify medication non-adherence specifically due to cost. We think a potential strategy to identify patients at increased risk for CRN may be to examine the date when patients fill prescriptions. When resources are limited, patients may wait to make purchases until they receive a monthly source of income. This phenomenon is especially prevalent among senior citizens, who often live on fixed incomes, especially from Social Security (SS). If data from multiple sources could provide information on both the timing of their income and when they have their prescriptions ordered, patients who order their prescriptions immediately after receiving their checks might be identified as at an increased risk of CRN. We think such patient behavior is a strong signal of the cost barrier to medication when the patient would like to purchase medication but is unable to do so until receiving the monthly SS check. Conceptually, we think this is a better measure than the medication possession ratio and filling gap analysis because these approaches do not take into account economic resource availability and thus suffer from low sensitivity and specificity, as non-adherence can be due to side effects, cultural preferences, or other non-cost factors.

Because SS checks are distributed on a monthly schedule based on the primary beneficiary’s birthdate, such an approach could be applied using a combination of data on prescription

ordering dates and birthday, which are available from a range of health care databases. This big-data approach, combining information from several dimensions of data, including survey data, EHR, and publicly available administrative information from the Social Security Administration, can jointly provide a comprehensive picture of patient behavior when faced with the financial burden of prescription medications.

Patient identification and CRN measure

The study was conducted at an urban academic medical center in 2014. Medicare patients who were hospitalized at the academic center or seen at the emergency department were approached in person for screening. Patients identified having at least one hospitalization in the prior year and consented were enrolled. We estimated that such a patient pool is at risk of, on average, 10 days of hospitalization in the ensuing year. This group of the patient population is suitable for our study because we estimated that such patients spent 2.6 times more than the average Medicare spending per enrollee and hence at high risk of CRN. Patients were surveyed on four different types of CRN behaviors in the previous 3 months when enrolled: (1) not filling or refilling a prescription; (2) delaying getting a prescription filled; (3) skipping doses to make the medicine last longer; and/or (4) taking smaller doses to make the medicine last longer to avoid cost. Each of these behaviors, regardless of how many among these four types, was considered CRN^{15,16}. The questionnaire on CRN is a part of an intake survey in a randomized study of patients with a high risk of hospitalization. The intake survey covers demographics, self-reported health status, and the physician-patient relationship. All patients enrolled in the study responded to this intake survey. This study received Institutional Review Board approval. The survey instrument on CRN was adapted from the Medicare Current Beneficiary Survey¹⁶, a nationally representative survey of Medicare beneficiaries, developed and administered by the Centers for Medicare and Medicaid Services (CMS), the federal agency administering the Medicare program. All the survey questionnaires on CRN were administered in person by trained research staff at the academic center.

Delaying filling prescription as a main CRN behavior

According to the Social Security Administration, among elderly Social Security beneficiaries, 53% of married couples and 74% of unmarried persons receive 50% or more of their income from Social Security, while 23% of married couples and approximately 46% of single individuals rely on Social Security for 90% or more of their income¹⁷. Therefore, Social Security plays a critical role in providing for patients' basic needs. We conducted a pilot study surveying 354 patients on CRN behavior including the following: a) not filling/refilling prescriptions, b) delays in filling/refilling, 3) skipping doses, and 4) splitting doses. We found that despite Medicaid coverage for this pool of high-risk patients, 29% reported CRN. Delay in filling/refilling was the most prevalent behavior among patients with CRN, and was highly correlated with the other CRN behaviors. For those who reported CRN, 81% delayed filling/refilling¹⁸. The importance of delay in filling/refilling prescription points strongly to the potential promise of identifying CRN behaviors based upon delaying filling/refilling prescription until the economic resources become available (i.e., ordering of medications upon receipt of monthly SS payments).

Matching the dates of ordering of prescription with the dates of SS payments

The dates of monthly SS payments to Medicare beneficiaries was determined by a standardized payment schedule set by the Social Security Administration that is based on the birthdays of the primary beneficiaries. Social Security beneficiaries receive the payment through their own earning history (i.e., primary beneficiaries), or through their spouses (i.e., secondary beneficiaries). For example, if the primary beneficiary's birthday is from the 1st to 10th days of the month, monthly benefits are paid on the second Wednesday of each month. Those with birthdays on the 11th to 20th days of the month are paid on the third Wednesday, and the remaining beneficiaries are paid on the fourth Wednesday of the month¹⁹. According to the Social Security Administration, nearly 89% of all Social Security payments were made by electronic direct deposits in 2010, but by March 2013, Social Security payments for all beneficiaries were made by electronic direct deposit²⁰. Thus, in 2014, all beneficiaries should have received their payments electronically on the same day.

Medicare applies the same classification system for primary and secondary benefit claimants. Medicare beneficiaries are identified uniquely by the Medicare program using Health Insurance Claim (HIC) numbers, which consists of the primary beneficiaries' Social Security number and an alpha or alphanumeric Beneficiary Identification Code (BIC) that indicates whether the beneficiary is the primary or secondary claimant. Since the Social Security payment date was based upon the primary claimant's birthday and the information about the birthday of the spouse of the secondary claimant is not readily available, it is not possible to ascertain the Social Security payment dates for those who are secondary claimants. We therefore restricted our analysis to primary claimant to the SS checks.

We extracted prescription information from the hospital's EPIC-based electronic health records (EHR) for patients in the year 2014. The EHR has detailed information on when the prescription was ordered and who ordered it. We compared the dates of prescriptions with the dates of Social Security payments and then created an indicator variable that reflected whether prescriptions were ordered within two days upon the receipt of Social Security payments. The 2-day cutoff was selected because it is hypothesized that patients will have enough time to utilize the available SS payment but is not too distal from the receipt of SS payment (and hence decrease the performance of the measure). We experimented by further extending the window, which resulted in decreased specificity.

Statistical analyses

We conducted a bivariate analysis to assess the mean and standard deviation of age for those reporting CRN. We then conducted a Chi-square test to evaluate the difference in CRN by 14 common chronic conditions. Next, we investigated the difference in the occurrence of ordering of Rx upon receipt of SS payment by those reported and did not report CRN. Informed by the above analysis, we then conducted a sequence of analysis using the below three sets of explanatory variables incrementally: 1) patients' age (less than mean + 1 s.d. for those reporting CRN), 2) the first variable plus occurrence of ordering of prescription upon the receipt of SS payments, 3) the second variables plus indicator variables for chronic condition which were found to be significantly associated with reporting CRN in the bivariate analysis.

We imposed such an age criterion because we wish to include as many patients reporting CRN while excluding those who were less likely to report CRN. Our previous research has suggested, for example, those with advanced age living in nursing home were less likely to report CRN.¹⁸ We also included chronic condition because some studies have indicated that disease burden was a significant risk factor for CRN and the addition of those variable may reduce the noise in the regression analysis, improving the model's predictive power. The information on chronic conditions were based on patient's self-reporting (e.g. single questionnaire for each condition) during the enrollment interview. We tested the incremental change in area under the Receiver Operating Curve (c-statistics) while incrementally including additional predictors into the model specification. The purpose of conducting this multivariable regression analysis was to demonstrate the overall model fitness and potential value to develop a CRN index by combining additional covariates when possible. We also conducted the Chi-square test to derive the sensitivity and specificity by combining the three sets of variables (age, ordering of Rx upon receipt of SS check, and one more aforementioned chronic conditions). To further understand the gravity of four types of CRN behaviors, we investigated the various combinations of CRN behavior. All analyses were conducted using the statistical software, Stata, Version 13²¹.

Results

Excluding Medicare beneficiaries who drew their benefits as secondary claimants yielded a final sample size of 559 Medicare beneficiaries for our study. The presence of any one or more of the four-type CRN behaviors was considered CRN. Out of 559 Medicare beneficiaries at high risk of hospitalization, 137 (25%) reported CRN. Those who reported CRN tended to be younger, with a mean age of 58.2 years ($p<0.01$). Table 1 illustrates the socio-demographic attributes and comorbid conditions of the respondents who reported CRN compared to those who did not. Those who had anemia, asthma, arthritis, back problems, depression, or digestive problems were more likely to report CRN.

Among patients reporting CRN, delaying filling or refilling prescriptions was the most prevalent behavior (71%), followed by not filling prescriptions (64%). 89 patients (65%) reported two or more CRN behaviors, while 42 patients (30%) reported three or more CRN behaviors. 30 (22%) reported all four types of CRN behaviors (Table 2).

There were a total of 5,663 outpatient prescriptions ordered for all 559 patients in the study in 2014. Table 3 shows the association between ordering a prescription on or within two days of receipt of SS check and reporting of CRN. Those who had ordering of prescription upon receipt of SS payments were more likely to report CRN ($p=0.04$), as illustrated in Table 3.

Table 4 shows the incremental change in c-statistics by adding exploratory variables into predictive model of CRN. The c-statistics increased from 0.57 to 0.61 when the prescription ordering on receipt of SS check entered the model in addition to age variable. The c-statistic further increased to 0.70 when six chronic condition indicator variables entered the predictive model. Most of these chronic condition indicators had large odds ratios except back problems, and digestive problem was statistically significant ($p<0.01$). When the index

was constructed requiring patients to meet all three criteria (within range of mean age+1 s.d., at least one ordering Rx on receipt of SS check, and at least one of the aforementioned six chronic conditions), the sensitivity was 0.58 and specificity was 0.67 (data not shown).

Conclusion and Discussion

In this study, we demonstrated that using a big-data approach to combining the survey data and EHR data, patients' behavior in delaying filling of prescription until the economic resources from SS payments become available can be measured, and that measure has some predictive value for cost-related medication non-adherence. However, because patients' behavior in CRN varies by disease burden and insurance status, this new approach requires further examination in various subgroups. We expect the measure will perform better in some patient groups than others, as patients with different disease burden may value the medication treatment differently, and hence exhibit differential degree of sensitivity and specificity in this measure.

This approach differs from the traditional adherence measures (e.g., filling gap analysis, possession ratio), as it combines the information of survey data, HER, and publically available SS payment data into a single measure. Because of patients' behavior was examined in an integrated manner with resource availability, prescription ordering, and self-reported CRN, this approach may more precisely reflect the cost barrier to medication adherence, setting it apart from other factors such as perceived effectiveness, side effects, and cultural preferences, which are usually a part of medication non-adherence.

This big-data approach in screening patients at risk of CRN can be implemented on macro-scale for a health plan or a micro-scale for a specific service population by a provider at low cost in the Medicare population as long as patients' medication ordering information is available and their Medicare HIC is known. For example, an automated reminder can be set up in the EPIC-type electronic medical record system to flag the patients at risk of CRN. This will facilitate patient-physician communication on the cost barrier to medications. Research has shown that discussions of prescription costs between patients and physicians are not common²² and patients often felt guilty about bring up the topic, while physicians usually do not initiate such discussion unless prompted. Such an electronic reminder system based on this readily available big-data CRN screening tool can effectively open the patient-physician communication of cost barriers to medication, allowing options such as changing tier of formulary, generic substitution, and partial waiver of out-of-pocket payments to be further discussed.

We think this method can be adapted to specific subpopulations of patients by adding variables to further improve its predictive power. For example, we noted that functional status and prior number of hospitalization are significant risk factors for CRN (^{23, 24}). The latter should be readily available in the medical claims, and the former can be used as additional aid when prompting physician to discuss the CRN with patients. More research is needed to quantify the benefits of including those risk factors in predicting CRN. The addition of chronic conditions in the multivariate regression model also suggested that the timing of prescription refills is robust across the various diseases, and the overall fitness of

the model can be improved by adding those covariates or tailoring the measure for certain specific patient groups.

There is a possibility that even after ordering a prescription, the ordered prescription can be abandoned. The abandonment is another example of non-adherence. The abandonment itself can be a separate measure of CRN. Unfortunately, such data is not available to researchers. Regardless, the combined information of ordering prescription and availability of SS check seems to be meaningfully associated with economic barrier to medication. In addition, non-adherence to one or more medications does not suggest that patients are non-adherent to all medication. In fact, patients may be selectively non-adherent to some medication they think are less valuable. There is little guidance in the literature in this regard thus far. Further research is much needed to understand how patients ration resources when faced with economic pressure.

Those who are dual eligible may also receive Social Security benefits although they are younger than 65 (66 for new retirees at present). A recent study suggested that Social Security Disability Income (DI) and/or Supplemental Security Income (SSI) are expected to be generally associated with Medicaid coverage for such patients²⁵. A detailed examination of such complex interaction is beyond the scope of this study. Further examination of such relationship in subgroups of patients receiving DI and SSI will help better understand these interactions.

We expect the CRN measure can be further refined by adding more covariates, such as the number of prescription. However, such a covariate may be correlated with income effect (i.e., larger number of prescription with lower income will result in higher likelihood of CRN) while directly affecting CRN through out-of-pocket payments. Such a complex relationship is beyond the scope of this study. Future study should focus on ascertaining the income effect and costs of medication simultaneously.

Our study has several important limitations. First, we are limited by sample size, so additional explanatory variables may suffer from Type II error, a challenge that could be addressed through a larger database with more patients. Second, this is a study in a single urban academic medical center and there can be significant geographic variation in prevalence of CRN. Thus, further research in the utility of such a screening tool in various patient populations is necessary. Our patient sample also included a significant portion of patients who were dually eligible. The heterogeneity among dual eligible and non-dual-eligible patients needs to be noted when generalization is warranted. Future research should focus on the subgroup of those patients at high risk of CRN. Third, although a delay in filling or refilling prescriptions is the most prevalent behavior in CRN, patients can be engaged with other CRN behavior such as splitting doses or skipping doses instead of delaying filling/refilling medications. Further research in this line will yield insight into the possibility of segmenting patients with CRN for discrete policy actions and economic incentives. Fourth, our study uses only cross-sectional data for one year of services, and thus, conclusions on time-varying factors cannot be established. Fifth, recall bias is likely an issue with survey data and hence should be noted.

Overall, we presented an approach to stratify the risk of CRN. The high prevalence of CRN in high-need, high-cost patients highlights the improvements needed to identify those patients and provide interventions through improved patient-physician communication, generic substitution, and insurance coverage. Finding solutions to decrease CRN among this population, a population who already consume a large amount of medical resources, is a significant step in reducing economic barriers to healthcare and improve patient outcomes.

Acknowledgments

This study is funded in part by a grant from Robert Wood Johnson (RWJ) Foundation 73487 (Meltzer), and a Pilot and Feasibility Grant from Chicago Center for Diabetes Translation Research (Zhang & Meltzer).

References

1. Madden JM, Graves AJ, Zhang F, et al. Cost-related medication nonadherence and spending on basic needs following implementation of Medicare Part D. *JAMA*. 2008; 299:1922–8. [PubMed: 18430911]
2. Briesacher BA, Gurwitz JH, Soumerai SB. Patients at-risk for cost-related medication nonadherence: a review of literature. *J Gen Int Med*. 2007; 22:864–871.
3. Goldman DP, Joyce GF, Zheng Y. Prescription drug cost sharing: associations with medication and medical utilization and spending and health. *JAMA*. 2007; 298:61–9. [PubMed: 17609491]
4. Tamblyn R, Laprise R, Hanley JA, et al. Adverse events associated with prescription drug cost-sharing among poor and elderly persons. *JAMA*. 2001; 285:421–9.
5. Mojtabai R, Olfson M. Medication costs, adherence, and health outcomes among Medicare beneficiaries. *Health Aff*. 2003; 22:220–9.
6. Gellad WF, Haas JS, Safran DG. Race/ethnicity and nonadherence to prescription medications among seniors: results of a national study. *J Gen Intern Med*. 2007; 22:1572–8. [PubMed: 17882499]
7. Piette JD, Heisler M, Wagner TH. Cost-related medication underuse among chronically ill adults: the treatments people forgo, how often, and who is at risk. *Am J Public Health*. 2004; 94:1782–7. [PubMed: 15451750]
8. Steinman MA, Sands LP, Covinsky KE. Self-restriction of medications due to cost in seniors without prescription coverage. *J Gen Intern Med*. 2001; 16:793–9. [PubMed: 11903757]
9. Wilson IB, Rogers WH, Chang H, Safran DG. Cost-related skipping of medications and other treatments among medicare beneficiaries between 1998 and 2000. *J Gen Intern Med*. 2005; 20:715–720. [PubMed: 16050880]
10. Soumerai SB, Pierre-Jacques M, Zhang F, et al. disabled Medicare beneficiaries: a national survey 1 year before the medicare drug benefit. *Arch Intern Med*. 2006; 166:1829–35. [PubMed: 17000938]
11. Piette JD, Wagner TH, Potter MB, Schillinger D. Health insurance status, cost-related medication underuse, and outcomes among diabetes patients in three systems of care. *Medical Care*. 2004; 42:102–109. [PubMed: 14734946]
12. Karter AJ, Parker MM, Moffet HH, Ahmed AT, Schmittiel JA, Selby JV. New prescription medication gaps: a comprehensive measure of adherence to new prescriptions. *Health Serv Res*. 2009; 44:1640–61. [PubMed: 19500161]
13. Hansen RA, Dusetzina SB, Dominik RC, Gaynes BN. Prescription refill records as a screening tool to identify antidepressant non-adherence. *Pharmacoepidemiol Drug Saf*. 2010; 19:33–7. [PubMed: 19998397]
14. Fairman K, Matheral B. Evaluating Medication Adherence: Which Measure Is Right for Your Program? *Journal of Managed Care Pharmacy*. 2000; 6:499–506.
15. Heisler M, Langa KM, Eby EL, Fendrick AM, Kaheto BiTU, Hette JD. The health effects of restriction on prescription medication use because of cost. *Med Care*. 2004; 42:626–34. [PubMed: 15213486]

16. Soumerai SB, Pierre-Jacques M, Zhang F, et al. Cost-related medication nonadherence among elderly and disabled Medicare beneficiaries: a national survey 1 year before the Medicare drug benefit. *Arch Intern Med.* 2006; 166:1829–35. [PubMed: 17000938]
17. Social Security Advisory Board. Old-age Benefits. https://www.google.com/?gws_rd=ssl. (accessed on June 9, 2015)
18. Zhang JX, Pandey K, Dong T, Lee JU, Meltzer DO. Patterns of cost-related medication non-adherence among older patients at high risk of hospitalization. Podium presentation at Society of Medical Decision Meeting 36th Annual North America Meeting. 2014
19. Social Security Administration. Schedule of Social Security Benefit Payments. 2014. <http://www.ssa.gov/pubs/EN-05-10031-2014.pdf>. (accessed on June 9, 2015)
20. Social Security Administration. Direct Deposit Of Social Security Benefits. <http://www.ssa.gov/oact/progdata/directdeposit.html> (accessed on June 9, 2015)
21. StataCorp. Stata MP - Parallel Edition. College Station, Texas 77845, USA:
22. Alexander GC, Casalino LP, Tseng CW, McFadden D, Meltzer DO. Barriers to patient-physician communication about out-of-pocket costs. *J Gen Intern Med.* 2004; 19:856–60. [PubMed: 15242471]
23. Zhang JX, Lee JU, Meltzer DO. Risk factors for cost-related medication non-adherence among older patients with diabetes. *World J Diabetes.* 2014; 5:945–950. [PubMed: 25512801]
24. Zhang JX, Meltzer DO. Risk factors for cost-related medication non-adherence among older patients with cancer. *Integr Cancer Sci Therap.* 2015; 2(6):300–304. [PubMed: 27087984]
25. Rupp K, Riley GF. Longitudinal Patterns of Medicaid and Medicare Coverage Among Disability Cash Benefit Awardees. *Social Security Bulletin.* 2012; 72(3)

Table 1**Respondent Characteristics and Cost-related Medication Non-adherence**

	Not reporting CRN N (%)	Reporting CRN N (%)	P-value
Characteristics	422 (100)	137 (100)	
Age: mean (s.d.)	63.8 (15.6)	58.2 (13.9)	<0.001
Gender: Male	160 (38)	53 (38)	0.87
Female	262 (62)	84 (61)	
Race: White	32 (8)	11 (8)	0.88
African-American	366 (88)	119 (87)	
Other	20 (4)	7 (5)	
Ethnicity: Hispanic	13 (3)	3 (2)	0.59
Non-Hispanic	409 (97)	134 (98)	
Insurance status			0.55
Dual eligible	194 (46)	67 (49)	
Non-dual eligible	228 (54)	70 (51)	
Education			0.86
Less than high school	83 (20)	26 (19)	
High school or more	339 (80)	111 (81)	
Comorbidities			0.03
Anemia: Yes	89 (21)	39 (28)	
No	326 (77)	92 (67)	
U/K or refused	7 (2)	6(1)	<0.01
Asthma: Yes	123 (29)	58 (42)	
No	296 (70)	77 (56)	
U/K or refused	3 (1)	2 (1)	0.03
Arthritis: Yes	218 (52)	86 (63)	
No	188 (45)	47 (34)	
U/K or refused	16 (4)	3 (2)	0.04
Back problem: Yes	163 (39)	67 (49)	
No	257 (61)	68 (50)	
U/K or refused	2 (<1)	2 (1)	0.29
Cancer: Yes	40 (9)	13 (9)	
No	380 (90)	123(90)	
U/K or refused	2 (<1)	1 (1)	<0.01
Depression: Yes	97 (23)	52 (38)	
No	318 (75)	83 (61)	
U/K or refused	7 (2)	2(1)	0.22
Diabetes: Yes	163 (39)	53 (39)	
No	253 (60)	79 (58)	
U/K or refused	6 (1)	5 (4)	

	Not reporting CRN N (%)	Reporting CRN N (%)	P-value
Digestive problem: Yes	102 (24)	63 (46)	<0.01
No	315 (75)	70 (51)	
U/K or refused	5 (1)	4 (3)	
Heart trouble: Yes	177 (42)	55 (40)	0.26
No	238 (57)	77 (56)	
U/K or refused	7 (2)	5 (4)	
Hypertension: Yes	315 (75)	103 (75)	0.32
No	101 (24)	32(23)	
U/K or refused	6 (1)	2 (1)	
HIV or AIDS: Yes	13 (3)	5 (4)	0.28
No	407 (96)	131 (96)	
U/K or refused	2 (<1)	1(1)	
Kidney disease: Yes	116 (27)	39 (28)	0.37
No	297 (70)	94 (69)	
U/K or refused	9 (2)	4 (3)	
Liver problem: Yes	24 (6)	13 (10)	0.12
No	389 (92)	119 (87)	
U/K or refused	9 (2)	5 (4)	
Stroke: Yes	65 (15)	24 (18)	0.23
No	349 (83)	111 (81)	
U/K or refused	8 (2)	2 (1)	

Table 2

Patterns of Cost-related Medication Non-adherence behaviors

No fill or refill	Delay filling	Skip doses	Split doses	N (%)
+	+	+	+	30 (22)
+	+	+		2 (1)
+		+	+	2 (1)
+	+			29 (21)
+		+	+	2 (1)
+		+		2 (1)
+			+	3 (2)
+				17 (12)
	+	+	+	6 (4)
	+	+		5 (4)
	+		+	2 (1)
	+			21 (15)
		+	+	6 (4)
		+		7 (5)
			+	3 (2)
87	97	60	54	137 (100)

Table 3

The Association between ordering of Rx on Receipt of SS Payments and Cost-related Medication Non-adherence

Occurrences of ordering of Rx upon receipt of SS payment	no CRN N (%)	CRN N (%)
0	176 (42)	41 (30)
1	111 (26)	46 (34)
2	67 (16)	22 (16)
3	31 (7)	15 (11)
4	18 (4)	10 (7)
5	9 (2)	0 (0)
6	4 (1)	2 (1)
7	3 (1)	0 (0)
8	3 (1)	0 (0)
10	0 (0)	1 (1)
Total	422 (100)	137 (100)

Legend: P=0.04 by chi-square test. The cut-off of dates is two days upon receipt of SS payment.

Table 4

Odds ratio of timed ordering medication in predicting cost-related medication non-adherence in multivariate logistic regression analysis

	Model I. Age only: Odds ratio (P-value)	Model II. Age + ordering of Rx when receiving SS payment Odds ratio (P-value)	Model III. + ordering Age of Rx when receiving SS+ chronic conditions Odds ratio (P-value)
Age (mean + 1.s.d reporting CRN)	2.35 (<0.01)	2.25 (<0.01)	2.22 (0.03)
1 or more ordering of Rx when receiving SS	–	1.55 (0.03)	1.47 (0.08)
Anemia	–	–	1.17 (0.50)
Asthma	–	–	1.25 (0.31)
Arthritis	–	–	1.36 (0.17)
Back problem	–	–	0.95 (0.83)
Depression	–	–	1.47 (0.09)
Digestive	–	–	2.25 (<0.01)
Area under Receiver Operating Curve	0.57	0.61	0.70

Legend: The cut-off of dates is two days upon receipt of SS payment. The presence of any one or more of the four-type CRN behaviors was considered CRN.