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Medication supply, healthcare outcomes and healthcare expenses: Longitudinal analyses of patients with type 2 diabetes and hypertension

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ABSTRACT

Introduction: Patients with chronic conditions largely depend on proper medications to maintain health. This study aims to examine, for patients with diabetes and hypertension, whether the appropriateness of the quantity of drug obtained is associated with favorable healthcare outcomes and lower expenses.
Methods: This study utilized a longitudinal design with a seven-year follow-up period from 2002 to 2009 under a universal health insurance program in Taiwan. The patients under study were those aged 18 years or older and newly diagnosed with type 2 diabetes or hypertension in 2002. Generalized estimating equations were performed to examine the relationship between medication supply and health outcomes as well as expenses.
Results: The results indicate that while compared with patients with an appropriate medication supply, patients with either an undersupply or an oversupply of medications tended to have poorer healthcare outcomes. The study also found that an excess supply of medications for patients with diabetes or hypertension resulted in higher total healthcare expenses.
Conclusion: Either an undersupply or an oversupply of medication was associated with unfavorable healthcare outcomes, and that medication oversupply was associated with the increased consumption of health resources. Our findings suggest that improving appropriate medication supply is beneficial for the healthcare system.

1. Introduction

Diabetes and hypertension are among the most prevalent conditions with significant complications and serious consequences [1]. Adherence to prescribed medications is a significant aspect of chronic disease management [2]. However, 36–93% of patients with diabetes [3] and 15–89% of patients with hypertension [4,5] are adherent. Previous studies have found that financial barriers, such as increased prescription co-payments or limited prescription coverage [6,7], were associated with a decline in the appropriateness of the quantity of drug obtained (by prescriptions filled and refilled). This may hold true in particular for patients with multiple chronic diseases because they may have to pay higher prescription co-payments, causing them greater financial burdens than those of the general population [8]. Furthermore, an undersupply of medications for patients with chronic conditions may increase the risk of costly adverse events that will require increased intensive and expensive healthcare utilization in the future [9].

Launched in 1995, Taiwan's compulsory National Health Insurance (NHI) program provides a comprehensive benefit package, including medication coverage with

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a low drug-cost-sharing requirement. For a typical physician visit, drug co-copayment is required when the drug expense exceeds 100 NT dollars per visit, and the amount of the drug co-payment ranges from 20 NT dollars to the ceiling of 200 NT dollars for every 100 NT dollars more of drug expenses per visit (one US dollar equaled 30 NT dollars in 2012). The low co-payment for medication under Taiwan's NHI system ensures that necessary medications can be obtained. However, due to the lack of referral arrangement, patients may receive duplicated prescriptions by multiple physicians or accumulate excess medications by earlier refills. Previous reports conducted in the United States have revealed that patients with hypertension or diabetes who were exempt from co-payments tended to have a very high rate of medication oversupply [10,11]. The generous prescription coverage under the NHI in Taiwan might result in medication oversupply as well.

An inappropriate medication supply can consist of either undersupply or oversupply, and the undesirable consequences caused by undersupply are different from those caused by oversupply. Medication undersupply reflects a patient's lack of follow-up visits or refill on schedule and may lead to the inadequate control of chronic conditions. On the other hand, an oversupply may be caused by the overlap of prescriptions by different physicians and increase the possibility that patients may not adhere to the optimal therapeutic regimen, for example, by taking too much medication or being confused about the use of their medications. Even if patients do not take duplicated medications, oversupply may lead to inefficient use of medications. Empirical studies have focused on the relationship between an undersupply of prescribed medications and healthcare outcomes and have found that undersupply may increase unfavorable healthcare outcomes [9,12]. However, only a small number of studies have examined the effects of both types of inappropriate prescription medication supply (undersupply and oversupply) on healthcare outcomes. Some studies found that poor adherence and receiving excess medication were both associated with higher hospital admissions [10,11,13,14]. However, Dilokkthornsakual et al. reported non-significant findings [15]. Studies on the relationship between medication undersupply and increased healthcare expenses are inconclusive [16–19]. The cost offset of lower medication expenses against total healthcare expenses remains controversial [20]. With respect to medication oversupply, a number of studies have demonstrated that patients with excess medications incur increased total healthcare expenses [10,11,13,14]. Therefore, a more comprehensive analysis of medication oversupply and undersupply for various chronic diseases is required to assess the association between medication supply and healthcare outcomes and expenses.

This study extends the existing literature in 4 ways. First, the majority of previous studies concerning the relationship between medication supply and healthcare outcomes and expenses were based on data from a single hospital [10,11,13,14]. In contrast, we used insurance claims data from a large representative population to reexamine this issue. Second, some studies have used cross-sectional study designs [10,13], which are subject to the problem of endogeneity owing to healthy user effects or healthy adherer bias. In this study, we used a multiyear longitudinal design to account for patients' unobserved time-invariant characteristics to reduce biased estimations and to ensure the temporality of the association [21]. Third, we examined the effects of medication supply on healthcare outcomes and healthcare expenses for two chronic conditions (diabetes and hypertension), which enabled us to investigate the potential differential impacts of medication supply. Finally, although the majority of previous studies were conducted in the United States, empirical evidence concerning the effects of medication supply on healthcare outcomes and expenses under Taiwan's NHI program might be valuable to other universal healthcare systems. The purpose of this study was to examine the effects of medication supply on healthcare outcomes and expenses for adult patients with newly diagnosed type 2 diabetes or hypertension.

2. Methods

2.1. Study design, data source and study population

This study employed a longitudinal analysis approach and evaluated claims data under the universal health insurance program in Taiwan from 2002 to 2009. We identified patients with newly diagnosed type 2 diabetes (ICD-9-CM: 250, excluding type 1 diabetes: 250.x1 or 250.x3) and patients with newly diagnosed hypertension (ICD-9-CM: 401) in 2002. Newly diagnosed patients were defined as lacking disease-related claims from 1999 through 2001 before the date of the first claim; the first claim date was referred as the "index date" in the analysis.

Patients were included in the analysis if they met the following criteria: (1) were at least 18 years old on the index date; (2) received a prescription for oral antihyperglycemic or antihypertensive medications at the physician visit on the index date of the initial diagnosis to ensure the appropriate timing of initial prescriptions for new patients; (3) had at least one prescription for relevant medications after the second year of the study period to ensure adequate follow-up; and (4) had no insulin prescriptions for diabetes treatment during any of the years in the study period. Because of the lack of sufficient information about daily insulin dosage in the claims data for each patient (e.g., whether patients were on the sliding scale insulin regimen), we were unable to precisely estimate the degree of medication consumption [22]. Starting from the index date for each patient, the subjects were followed for seven years, which was defined as the study period. Using the above criteria, we recruited 11,580 patients with diabetes (81,060 patient-years) and 17,605 patients with hypertension (123,235 patient-years). In this study, the unit of observation was a patient-year, yielding seven observations per patient over the study period.

2.2. Outcome measures

The first set of outcome variables were related to healthcare utilization attributable to the inappropriate control of diabetes or hypertension and were measured by "whether the patient was hospitalized or had an emergency