



Changes in prevalence of diabetic complications and associated healthcare costs during a 10-year follow-up period among a nationwide diabetic cohort



Hung-Lin Chen^a, William Wei-Yuan Hsu^{b,c}, Fei-Yuan Hsiao^{a,d,e,*}

^a Graduate Institute of Clinical Pharmacy, College of Medicine, National Taiwan University, Taipei, Taiwan

^b Department of Computer Science and Engineering, National Taiwan Ocean University, Taiwan

^c Institute of Information Science, Academia Sinica, Taiwan

^d School of Pharmacy, College of Medicine, National Taiwan University, Taipei, Taiwan

^e Department of Pharmacy, National Taiwan University Hospital, Taipei, Taiwan

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ABSTRACT

Objective: Long-term health and economic consequences of diabetes mellitus are of significant importance to health policy makers to identify the most efficient interventions for disease managements. However, existing data are mainly from simulation models instead of "real-world" data. The objective of this study was to longitudinally evaluate the changes of prevalence of diabetic complications and associated healthcare costs in a nationally-representative diabetic cohort.

Methods: We used the 2000–2011 Taiwan's Longitudinal Health Insurance Database (LHID) to conduct a population-based cohort study of 136,372 patients with type 2 diabetes. Diabetic complications of each patient were calculated annually after the cohort entry by the adapted Diabetes Complications Severity Index (aDCSI) score (sum of diabetic complication with severity levels, range 0–13) using diagnostic codes recorded in the LHID. Study subjects were further categorized into six subgroups according to their aDCSI score (0, 1, 2, 3, 4, 5+) at cohort entry. Healthcare utilizations (including outpatient and inpatient visits) as well as direct medical costs for the six subgroups were estimated annually using patient-level data from the LHID.

Results: We found the severity of diabetic complications increased over time, especially for patients with aDCSI score of 2 and above at cohort entry (at 10 years of follow-up: aDCSI = 0 (cohort entry), 2.37; aDCSI = 1, 3.59; aDCSI = 2, 4.60; aDCSI = 3, 5.14; aDCSI = 4, 5.96). There were significant differences in healthcare utilizations and associated medical costs among patients stratified by aDCSI score (e.g. at 1 year after cohort entry, mean counts of inpatient visits: 0.14 vs. 1.81 for aDCSI = 0 vs. 5+). Relatively high healthcare utilizations and associated medical costs in the first year of cohort entry were observed for patients with aDCSI score of 4 and above at cohort entry.

Conclusions: We provided the important empirical data for patient-level longitudinal changes in diabetic complications and associated healthcare utilization and medical costs among patients with diabetes.

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1. Introduction

Diabetes mellitus is a chronic complicated illness that leads to multiple long-term complications, including cardiovascular diseases, nephropathy, neuropathy and retinopathy. These diabetic complications may cause patients incapable of walking, renal dysfunction,

visual loss and even death. Diabetic complications are also reported to be associated with significant economic burden. While the average cost of healthcare for patients with diabetes was 4.3 times higher than for patients without diabetes (Lin, Chou, Lai, Tsai, & Tai, 2001; Lin, Chou, Tsai, Lee, & Tai, 2004), a substantial proportion of cost was attributed to the diabetic complications, responsible for 38% of total medical cost (American Diabetes Association, 2013).

Despite its importance, few studies have examined the longitudinal changes of diabetic complications and related healthcare costs. Most existing studies have adopted the cross-section study design and reported only point estimates of annual prevalence of diabetic complications and associated costs (Chang, Weiner, Richards, Bleich, & Segal, 2012a; Rosenzweig, Weinger, Poirier-Solomon, & Rushton,

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* Corresponding author at: National Taiwan University, College of Medicine, Graduate Institute of Clinical Pharmacy, Room 220, 33, Linsen S. Rd, Taipei 10050, Taiwan. Tel.: +886 2 33668787; fax: +886 2 33778780.

E-mail address: fyhsiao@ntu.edu.tw (F.-Y. Hsiao).

2002; Ward, Alvarez, Vo, & Martin, 2014). Furthermore, some of them were limited to specific diabetic complications (such as cardiovascular complications (Straka, Liu, Girase, DeLorenzo, & Chapman, 2009) and retinopathy (Woung, Tsai, Chou, et al., 2010)) and related medical costs. For example, Woung et al. (2010) reported significant increase of costs associated with diabetic retinopathy (US \$1566 in 2000 to US \$3326 in 2004 ($p < 0.001$)). Some studies also were limited to incremental costs between diabetic cohort and their non-diabetic counterparts only (Brown, Pedula, & Bakst, 1999; Farshchi, Esteghamati, Sari, et al., 2014; Straka et al., 2009; Woung et al., 2010).

For example, Straka et al. (2009) reported that diabetic patients hospitalized for a cardiovascular event incur higher costs for cardiovascular care than their non-diabetic counterparts. Furthermore, most longitudinal studies only included diabetic patients free of complications but not diabetic patients with different severity of complications at cohort entry (Farshchi et al., 2014; Woung et al., 2010). In addition, some of the existing studies were limited to data derived from simulation models (Zhuo, Zhang, & Hoerger, 2013) instead of "real-world" data (Brandle et al., 2003; Caro, Ward, & O'Brien, 2002). To sum up, studies on the long-term healthcare and economic burden of diabetes mellitus associated different diabetic complications in the "real-world" are still scarce.

To address these limitations, the purpose of this study was to longitudinally evaluate the changes in the prevalence of diabetic complications and associated healthcare costs during a 10-year follow-up period in a nationally-representative diabetic cohort by using Taiwan's National Health Insurance Research Database (NHIRD).

2. Materials and methods

2.1. Data source

The NHIRD is a nationwide database composed of anonymous eligibility and enrollment information, as well as claims for visits, procedures, and prescription medications of more than 99% of the entire population (approximately 23 million residents) in Taiwan (Hsiao, Yang, Huang, & Huang, 2007). The longitudinal nature of NHIRD permits one to identify a cohort based upon diagnoses, health services and drug utilization, to track medical history, and to establish a prescription drug profile. This claim database has been reviewed routinely by the National Health Insurance Administration (NHIA) of Taiwan to ensure its completeness and accuracy. It has been the source for numerous epidemiological, healthcare and economic researches published in peer-reviewed journals (Lin et al., 2001; Lin et al., 2004; Lin, Huang, Wang, Yang, & Yaung, 2010; Wou et al., 2013).

We used the 2000–2011 Longitudinal Health Insurance Database (LHID), which contains claims data of three million beneficiaries (approximately 13% of the total population) randomly sampled from the NHIRD, as our data source. Because the LHID was retrieved from the NHIRD, the distribution of age, gender and average insured payroll-related amount of the LHID is not different from the original NHIRD (Nichols, Glauber, & Brown, 2000).

2.2. Study cohort

Our study cohort included patients diagnosed of diabetes mellitus between January 1, 2000 and December 31, 2011. For inclusion in our analytic cohort, we defined patients as having diabetes mellitus if they had at least one inpatient or two outpatient visits with a diagnosis of diabetes mellitus (*International Classification of Disease, Ninth Revision, Clinical Modification* (ICD-9-CM) = 250.xx, 648.0 (diabetes mellitus with pregnancy) and 362.0 (diabetic retinopathy)) separated by at least 28 days. Patients filling with a prescription for treatment of hyperglycemia were also included. However, if the prescription was only for metformin or insulin alone, the patient was also required to

have a relevant code for diabetes mellitus for cohort entry in this study. The date of the earliest diagnosis of diabetes mellitus was defined as the index date of our study cohort.

To restrict our study population to patients with type 2 diabetes mellitus, those with only diagnosis of type 1 diabetes mellitus (ICD-9-CM code = 250.x3) were excluded. Patients were further excluded from this study if their age at index date is younger than 18 or unknown. To investigate the annual pattern of individual's overall severity of diabetes complication and related healthcare utilization, we followed all eligible patients with full medical and pharmacy coverage longitudinally. Based on this inclusion criteria and the availability of our data (2000–2012), a person diagnosed in 2001 could contribute up to 10 years of post-diagnosis data while a person diagnosed in 2007 could contribute up to 5 years of post-diagnosis data. Sample size is therefore larger for years close to diagnosis (Appendix A).

2.3. Study variables and outcome

2.3.1. Adapted Diabetes Complications Severity Index (aDCSI) score and aDCSI complication count

We used the adapted Diabetes Complications Severity Index (aDCSI) (Chang et al., 2012a; Chang, Weiner, Richards, Bleich, & Segal, 2012b) to measure the disease progress over time among our diabetic cohort. The aDCSI has been reported to be a useful tool for prediction of risk of hospitalization and healthcare costs (Chang et al., 2012a, 2012b; Young, Lin, Korff, et al., 2008). The performance of aDCSI in predicting risk of hospitalization and healthcare cost has been validated in the NHIRD in our previous study (Chen & Hsiao, 2014).

To calculate the aDCSI score and aDCSI complication count, we used the claims coded with ICD-9-CM codes and applied classification method developed by Young et al. (2008), modified by Chang et al. (2012b) study, and validated in our previous study (Chen & Hsiao, 2014). The aDCSI consists of severity score (0, 1, and 2) from 7 categories of diabetic complications: retinopathy, nephropathy, neuropathy, cardiovascular, cerebrovascular and peripheral vascular disease, and metabolic disease. The sum of aDCSI score ranges from 0 to 13. The aDCSI complication count is a count of any complication in the 7 categories and ranges from 0 to 7. For example, if a diabetic patient has retinopathy (severity = 1) and nephropathy (severity = 2), then the aDCSI score for this patient is 3 and the aDCSI complication count for this patient is 2.

2.4. Healthcare utilization and costs

This study used a longitudinal study design. All study subjects were categorized into six groups (0, 1, 2, 3, 4, and 5+) based on their aDCSI score in the first year of cohort entry. The categorical aDCSI score (0, 1, 2, 3, 4, 5+) was reported to be significantly positively associated with risks of hospitalizations in previous studies (Chang et al., 2012b; Chen & Hsiao, 2014). A 10-year follow-up period was applied for each study subject started from the cohort entry date. All direct medical costs and inpatient/outpatient visits were obtained from the claims of NHIRD during the 10-year observational period. Total costs were classified into several subcategories, including outpatient, inpatient costs and drug costs. All costs were reported as 2013 U.S. dollars (currency exchange rate of December 1, 2013, 28 New Taiwan dollars = 1 US dollar).

2.5. Statistical analysis

Annual changes in aDCSI score and related healthcare costs among patients with diabetes were represented as mean $\pm$ standard deviation (SD). Comparisons between groups were conducted by using ANOVA test for continuous variables and Chi-square tests for discrete variables. Chow test, a statistical test of whether the

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