Research Article

Characterizing Changes in Medical Expenditures and Outcomes Associated with Health Policy Implementation: The Case of Hospital Care for Type 2 Diabetes in China

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Abstract

Background: Chinese health care policy is continuing being designed and implemented towards the goal of generating overall improvement in healthcare delivery including the care of diabetes that has become one of the most prevalent chronic conditions in China. This study evaluated the impact of two major health policy implementations on costs and outcome of hospital care for patients with diabetes. **Methods:** The 2015-2018 hospital discharge data for diabetes in China were analyzed. The five dependent variables included total charges per discharge, length of stay, daily charges, the percentage of drug charges as the total charges, and the percentage of medical service fee as the total charges; The main independent variables was the implementation of the merge of two health insurance programs and the zero mark-up drug pricing policy. Generalized linear regression and generalized logistic regression were applied with covariates being used included patient age, sex, and occupation, as well as the year. **Findings:** After the policy implementation, decreases occurred in the length of the hospital stay (-1.35 days), total charges per discharge (-540.8 yuan), daily charges (-43.3 yuan), and the percentage of drug charges (-7.85%).The percentage of medical service fees, as desired, increased by 1.47%. **Conclusion:** The health policy implementations show certain promising effects on hospital care for diabetes at tertiary hospitals in regard to cost, hospital revenue structure, and clinical outcomes. Nevertheless, caution is warranted to assess the effectiveness and efficiency of the entire healthcare delivery system consisting of the three-tier hospitals.

Keywords: Health insurance; Drug pricing policy; Hospital care; Diabetes; China

Background

Both worldwide and in China, health care policy is continually being redesigned towards the goal of generating health care system improvements that reflect themselves in reduced mortality and morbidity. Dai, et al. [1] analyzed health care policy in China and identified three key periods of change that differentially impacted health care mechanisms and subsequently, health care outcomes. From 1950 to 2009, health care policies increased the number and rates of for-profit hospitals, clinics, and other facilities. During the now historic 2009 health care reforms, public insurance and public health services were expanded. Similarly, primary care health delivery systems were expanded in terms of numbers and public accessibility, medications were more easily accessed as a result of the implementation of a national drug system, and critically, public hospital reforms were made.

Despite its status at the most comprehensive reform, additional major policy changes were made after the 2009 health policy reforms. Policies were passed to expand the percent of the population covered by health insurance to 95% or more of the population so that medical care security was assured. This effort involved systems to insure farmers, urban residents, and impoverished persons whether they were urban and/or rural residents. A second set of post 2009 health care refunds expanded the areas covered via government financial resources. These sets of policies were designed to improve the health of current and/or prospective mothers and their born and/or unborn children. Children and youth were further protected via access to age-appropriate immunizations. Expanded mental health services were also made available to the overall public. Aging citizens also had access to more health care services. The previously unaddressed need for greater health education so that services could be used was also included in these latter public health policy changes. Of particular importance to this study, these new public health services were inclusive of strategies, tools, and services to advance the management of chronic diseases. Relatedly, health education was provided so that disparities in health knowledge across China's diverse geographical areas and population groups could be narrowed.

Another post-2009 health care reform made in China involved the restructuring and expansion of primary care. This policy centered around the implementation of urban community services that made primary care more accessible to persons in cities, the construction of a multi-layered system of basic health services to support persons in rural areas, and importantly, the formal integration of Chinese traditional medical practices into the newly re-organized health care systems. This policy change alone was momentous for that it implicitly endorsed the legitimacy of traditional Chinese medicine through its inclusion as a part of post-2009 health care reform.

Another set of post-2009 reforms were directed towards the pharmaceutical component of China's health care system. This system altered pricing of drugs by establishing a drug list and drug prices that reflected government established core prices. This measure was taken in order to contain excessive drug markups.

Finally, post-2009 reforms also included alterations in hospitals' operations, ownership, regulations, quality standards, as well as revenue monitoring. It is important to note that the described policy changes did not occur as a major mandatory overturn of the 2009 massive policy changes. Rather, many of the policies complemented and/or were simply co-executed with past health care reforms. Interactively, the total volume of policies defined the populations served and the service scope of the areas and providers, expanded the subgroups to whom health services were available, and altered and modified the range of health needs for which health care become available as well as modified the outcomes associated with the receipt of health care [2]. Specifically, reforms such as these allowed some patients to no longer be restricted to a township and/or county hospital but to directly access tertiary hospitals. Tertiary hospitals, given their higher budgets and greater levels of resources, were capable of increasing the quality of care for those hospitalized for complications of chronicity such as Type 2 diabetes.

As can be seen, China has engaged in intensive health care policy development and implementation over recent decades. Xu and Mills [3] identify some of the challenges and responses that China's policymakers have experienced as they sought to expand health care access and quality for a population that now exceeds 14 million geographically, culturally, and socioeconomically unique subpopulation groups. While China's most overarching sets of reform measures were, as mentioned, initiated in 2009, key health care policy changes also took place before this period. Specifically, relative to policies to promote health care access, China developed three basic medical insurance programs for different populations to increase access and reduce the financial burdens of healthcare. The initial one, the *Urban Employee's Basic Medical Insurance* (UEBMI) was implemented in 1998. The primary purpose of this policy was that of providing medical insurance for the urban working population. The *New Rural Cooperative Medical System* (NCMS) began in 2003. This voluntary participation program provided financial subsidies that allowed rural residents to have access to health care [4]. The *Urban Resident Basic Medical Insurance* (URBMI), established in 2007, was explicitly implemented to cover urban residents who were not employed. In order to further improve benefits coverage, the New Rural Cooperative Medical System (NCMS) was merged with the Urban

Resident Basic Medical Insurance (URBMI). Coupled with other policies that supported economic development, these basic medical insurance programs gradually expanded their coverage areas and improved benefit coverage for major segments of the population.

One commonality shared by these three policy changes was the objective of making healthcare more equitable and efficient. This is not to say that the potential effects on healthcare did not vary in regard to out-of-pocket payment of patients, access to health care, costs of care, fee structure, and other possible outcomes. However, assessment studies also found that the number of hospitalizations increased as these policies that expanded insurance coverage were passed [5].

According to Yip and Hsiao [6], driven by philosophical and ideological changes regarding the role of government and the relationship between government and its citizens, these various programs delivered to China a system of health care policies that are oftentimes described as universal care. The applicability of this term is confirmed by the fact that greater than 95 percent of China's overall population were provided access to insurance under these measures.

However, while the central government in China makes decisions on general health policies, local areas/regions retain the authority to determine when these policies will be implemented. Accordingly, it becomes possible to geographically, epidemiologically, and institutionally disaggregate various regions of China in order to assess the impact of various health policy changes. This paper seeks to assess the changes that were associated with two policy changes that were implemented in a particular area of Northern China in 2017. Specifically, the study was designed to determine whether significant improvements occurred for patients hospitalized for diabetes at a tertiary hospital in Northern China before and after selected national health policy changes that began in 2009 were eventually implemented in the research area in 2017. Before describing the exact research questions and the applied methodologies, it is necessary to first describe the epidemiological importance of policies that improve diabetes outcomes in China.

Type II Diabetes and Health Policy Change in China

Zhou, et al. [7] describe some of the illnesses and diseases that have served as a prompt for further policy changes. One of these illnesses and diseases has been Type 2 diabetes. Wang [8], utilizing data from a sample of 170,287 persons that was collected in 2013, identified a diabetes prevalence rate of 10.9% and a pre-diabetes prevalence rate of 35.7% for this highly populous country. Such data positioned China as number one in the world in terms of diabetes. The analysis of the data also revealed significant differences in prevalence rates by ethnicity and religious status. Differences also existed by other demographic variables such as sex, age, urban/rural status as well as by clinically significant

factors such as body mass index and socioeconomic determinants of health status such as education.

Other research has also identified differential patterns of diabetes vulnerability across various populations in China. Long, et al. [9] further extended one's understanding of the linkages between health policy and diabetes in China through findings which revealed that age, gender, education, urban/rural status, and other known differences in the prevalence and incidence of Type 2 diabetes were also accompanied by differential care as a result of insurance type. More explicitly, despite the fact that the *Urban Employee's Basic Medical Insurance* (UEBMI) and Rural New Cooperative Medical Schemes (RNCMS) provided collective coverage to more than 95% of all persons living in China, disparities existed in access to diabetes care.

Such findings reconfirmed earlier research by Li and colleagues [10] which had urged policymakers to assess strategies to prevent the progression of the growing diabetes prevalence rates in China by focusing on secondary prevention interventions. It was argued that such a focus would partially deflect the hospital costs that accrue when complications due to diabetes emerge. But, with hospitalization services and costs commingling with issues of geographic disparities as well increasing costs due to complications requiring hospitalizations, it is less than surprising that the need for new policies based upon narratives regarding investment and reimbursement thresholds emerged. Indeed, advocacy for additional health policy change occurred despite the fact that the Chinese government had recently invested an estimated 1.51 trillion in the implementation of new health care policies [11]. However, despite the level of policy investments in health care that had been made in the past, the reform effort had not sufficiently focused upon hospitals and the comparative outcomes of the multi-tiered hospital system. In particular, Wang et al. [12] as well as other researchers made recommendations for changes in the overall management of diabetes by both medical providers and via medical insurance. However, for the most part, these recommendations have not been fully implemented throughout all regions of China. Yet, Wang, et al. [13] using data from Shanghai, Beijing, Guangzhou, and Chengdu, found that complications of diabetes, the diabetes disease course, drug therapy, insulin treatment, and other areas were drivers of direct medical costs across the different cities.

But, coverage for care that reduces the complications of diabetes before hospitalization and/or which defines the range of services after hospitalization are innately linked with those health policies that define the terms of the medical insurance. Accordingly, the research by Wang, Liu, Li, and Liu [13] also assessed the impact of China's 2009 healthcare reform in order to identify whether variable outcomes, such as total number of patients hospitalized, average length of stay, costs per stay, and

costs of medications among others, occurred across the three operative healthcare systems. Again, the primary inquiry focused around the assessment of the impact of the 2009 healthcare reform in China.

Health care policy, even if formulated to enact macro-level changes, affects the overall healthcare system by triggering change at the micro-level. Continuing the inquiry of scholars into the system-level impact of Type 2 diabetes, Hu et al. [14], using both empirical data on China's Type 2 diabetes-related cases as well as a systematic review of secondary research, reiterated the fact that both before and after the 2009 policies change, additional policies were needed to decrease two critical variables: 1) the prevalence rate of Type 2 diabetes; and 2) the rate of progression of diabetes in terms of severity. These changes were needed in order to ultimately prevent the acceleration in diabetes-related hospitalization and outpatient costs. While policies to reduce the progression to severe diabetic complications were needed, policies that are inclusive of strategies to decrease hospital readmissions were also deemed to be important.

Effective policies to contain the hospitalization costs for patients with Type 2 diabetes can only be developed if clarity exists regarding those forces that affect their level and magnitude. Cao [15], utilizing data from 2,970 medical files in the Hospital Information System for a hospital in China that is rated at the highest level, sought to identify key determinants of rising costs for the period 2005-2012. Changing policies over this time period were excluded. The findings were illuminative. The study concluded that the medical insurance programs in China did not reward fewer and less complex complications. The medical insurance also did not support decreased hospital stays, reduced risks of readmission, nor strategies that decreased the number of emergency admissions - another variable that is positively associated with reduced hospitalization costs for patients with Type 2 diabetes. Other factors that were associated with high hospitalization costs for patients with Type 2 diabetes that are subject to policy alterations included patient's age and gender. Interestingly, the form of payment was also correlated with hospitalization costs for patients with Type 2 diabetes.

Numerous other investigators have also conducted research that has helped to further identify the relationship between health care policy change and the nature and costs of hospitalization for diabetes in China. Liu, et al. [16] utilized cross-sectional survey data for the years 2011 and 2012 from hospitals located in a segment of Shandong Province - an area covered by the New Cooperative Medical Scheme (NCMS). NCMS altered its policies by increasing access, expanding the benefits coverage, and ensuring provider interest by shifting to a fee-for-service payment reimbursement form for providers. These investigators concluded that these policy changes were associated with inflated medical costs in the three research counties.

In a more recent study, Liu et al [17] sought to identify micro-level policies for reducing the costs and high readmission rates among hospital patients in Tianjin, China - a city known for its avant-garde role in initiating and being responsive to health care policy changes. Utilizing data from 73,144 diabetes patients who were hospitalized from 2008 to 2013, this study re-confirmed the need for policies that address the progression of diabetes by reducing complications of diabetes as well as comorbidities such as hypertension, chronic heart failure, and other conditions that accompany the heterogeneous forms of Type 2 diabetes [18]. This study also identified the need for preventive measures to reduce the higher costs that are associated with higher readmission rates. Specific types of preventive measures needed included early diabetes screenings especially for persons with a family history of diabetes, policies that can reduce medicine and other related hospital costs, changes in reimbursement ratios, and other types of reforms.

Research by Chen et al. [19] specifically analyzed changes in policies that are related to readmission rates. This study also specifically focused upon strategies that can decrease Type 2 diabetes costs that are associated with the length of stay (<.05). The authors found that length of stay is significantly linked with two key policy-related variables - type of medical insurance and the presence of complications. Bao et al., using data from 2006-2010, also confirmed the key role of diabetes complications, readmission rates, and length of stay in elevating health care costs in China for Type 2 diabetes.

Health policies have also focused on improving overall health care including hospital performance in regard to effectiveness and efficiency. Similarly, policies that elevate the interaction between the central government and the local government have been an important aspect of China's historic and more recent health care reform. For example, public hospitals in China could, under past policies, increase their financial revenues by charging a 15% price mark-up for drugs. Recently, the policy direction of China's public hospital reform led to the implementation of zero markup drug reform, the implementing of a medical insurance diagnosis-related group payment system, improving hospital management such as limiting the drug proportion of hospitalization expenses, average length of stay, bed rotation rate, etc. The government's changed health policy also sought to more closely link the quality of medical service, the quantity of physician's labor, and other outcomes to hospitals' payments. Some existing studies have found that the zero-markup drug reform has reduced drug charges and patients' burden to a certain extent [20, 21].

Given the extensiveness of such findings, it is unsurprising that China's health care system has not merely experienced health care reform, but continues to do so. Fu [22], however, commends

China on its committed role in using "...policy experimentation under hierarchy" to advance overall health outcomes. Nevertheless, studies that assess whether policy changes are associated with improved health outcomes remain vital to continued progress. In this regard, this study, building on the past research on health policy reform in China, aimed to evaluate potential impact of the selected policies, when finally implemented in a region, on hospital care of patient with diabetes. Two research questions were specified: 1) Were costs of hospitalization for persons with diabetes affected between the pre- and post-policy change implementation period for this study site? and 2) Did hospital care vary among diabetic patients with different health insurance programs/status? Findings of the study provide a new piece of empirical evidence in examining effectiveness and efficiency of the recent health policy reforms in China.

Methods

In order to answer the above questions, this study compared prior impacts of policy change with outcomes associated with post-policy changes. The period of the study was data from January 1, 2015 to December 31, 2016 for the prior-policy period and from January 1, 2017 to December 31, 2018 for the post-policy period.

Data Sources and Study Population

Before/after data for the study was collected from the Department of Endocrinology in a general public tertiary hospital in the Northern region of China. Data were extracted for all patients who had been admitted to the hospital during the study period. All patients with diabetes as the principle diagnosis served as the initial universe for the study. For the prior policy change period, 2,661 of patients were included. In contrast, for the post-policy change period, 3,212 diabetes case files were examined. Final cases selected for inclusion in the study included only those with completed fields for principal diagnosis, discharges, length of stay equals or shorter than 60 days, and other information. In addition, we used similar national statistics from 2015 to 2018 to verify our findings. This study was approved by the ethical review committee of Qing-Huang-Dao First People Hospital, China.

Measures

Seven dependent variables reflecting hospital performance were examined. These measures were divided into two categories: cost-related and clinical-related characteristics. The five cost-related measures were total charges per discharge, length of stay, daily charges, the percent of drug charges as total charges, and the percent of medical service fee (the service fee including labor cost focused physician fee, nursing fee, and other fees related to labor costs) as the total charges. The two clinical-related characteristics were chronic complications related to micro-circulation conditions, a dichotomous variable with a value of "1" indicating Yes and a value of "0" indicating No, and chronic complications associated

with macro-circulation conditions (a dichotomous variable with a value of "1" indicating Yes and a value of "0" indicating No) were used. The complications were identified by using the ICD-10 codes. More specifically, as is known, the policy changes implemented can be revealed in hospitalization rates and costs through several mechanisms. At the first level, the implementation of policies that expand insurance coverage can bring into the health care system persons with undiagnosed diabetes and/or persons whose diabetes has already advanced to the stage in which micro-complications and/or macro-complications are so severe that hospitalization is required. In this case, post-reform hospitalization rates for diabetes that reveal an "increase" in diabetes complications "post-reform" could be interpreted as a positive policy outcome. Simultaneously, because health policy changes that increased access to health care can lead to early diabetes screening and improved patient and physician management, diabetes hospitalizations that are accompanied by a decrease in micro- and macro-complications can also be interpreted as a positive policy outcome in the post-policy period. Mao, Yip, and Chen [23], argue, however, that past policy reforms have included insufficient strategies to reduce micro- and macro-complications of diabetes. Of particular interest to this study, however, these researchers found that persons living in the northern regions had a prevalence rate of diabetic complications that was twice as high amongst the general populations-1.4% in comparison to 0.7%. However, they also found that 26.5% of persons with diabetes in Northern China had diabetes complications relative 15.7% of persons with diabetes in Southern China. Thus, the rate was 68.79% higher for northerners. Persons living in the rural areas of Northern China had even greater risks of a diabetes complication based upon Mao, Yip, and Chen's study. Thus, despite the difficulty of interpreting changes in hospitalizations with micro- and/or macro-complications, the variables were included in this study.

However, the key independent variables included payer and two policy variables. Payer was categorized as UEMBI, URBMI, NCMS, self-pay, and other. The first policy variable, Policy1, was introduced as a dummy variable that was created to indicate the merger of URBMI and NCMS (the implementation started on January 1, 2017 in the local area where the hospital was located). The second policy variable, Policy2, was a dummy variable that was assigned to indicate the implementation of the zero-mark-up of prescription drug sales for hospitals (the implementation started on August 1, 2017 in the local area where the hospital was located).

The policy variable-zero-mark-up of prescription drugs for hospitals also relate to the outcomes associated with diabetes programs both before and during hospitalizations. Hospitalization rates and hospitalization outcomes require access to prescription drugs both before and/or after and during hospitalization. The adoption of the zero-mark-up of prescription drug sales to hospitals policy can also affect diabetes outcomes. Thus, the pre- and post-

analysis also included changes in mark-up on prescription drugs as a variable of interest.

Analytical Techniques

The unit of analysis was hospital discharge. Generalized linear regression was used for continuous dependent variables, such as total charges, daily charges, the percentage of drug cost, the percentage of medical service fee, and length of stay, respectively. Generalized logistic regression was used to analyze the two dichotomous dependent variables, microcirculation complications and macro-circulation complications. Covariates included the patient's demographics, such as age, sex, and occupation, as well as year. Due to a high level of multicollinearity, existing between the two policy variables only the Policy 1 variable was included in the multivariable analyses [24]. The sensitivity analysis was conducted by using Policy 2 to replace Policy 1 in the analytical modes, which yielded similar results. The study was approved by the hospital's ethic committee.

Results

Table 1 provides the unadjusted descriptive results of patients hospitalized for diabetes by insurance type before and after the implementation of Policy 1 and Policy 2 in the selected hospital in northern China. It reveals that if hospitalizations for diabetes are used as a proxy variable for increase to health care, this objective was achieved. Whether due to absence of insurance and/or another reason, an increase occurred in the total number of persons able to access needed hospitalizations for diabetes between the pre- and post-policy change implementation period. For persons insured by the Urban Employee's Basic Medical Insurance (UEBMI),

the number of persons hospitalized increased from N=1,885 to N=2,059, a change of 9.23%.

During the pre-policy implementation period, the Urban Residents Basic Medical Insurance (URBMI) had fewer diabetes hospitalizations (N=229) than the New Rural Cooperative Medical System (NCMS) (N=394). This difference of 165 hospital admittees was 72.05% higher during the base period. This difference was less than surprising since the NCMS was the dominant insurance in all rural areas. Policy 1 impacted enrollments in NCMS since it merged URBMI and NCMS and the hospital used for the study was located in an area that did not begin implementation of the merger until 2017. Accordingly, the analysis indicated that URBMI experienced a 207.42% increase in hospitalizations for diabetes (N_2=702, N_1=229). Diabetes hospitalizations decreased by 252.8% (N_2=87, N_1=394) among persons insured by NCMS as, consistent with the new policy, they merged with URBMI. Self-Pay diabetes hospitalizations increased by 137.25% (N_2=362, N_1=153). Thus, during the post-policy period, a greater number of persons with diabetes had access to hospital care when their disease manifested itself in ways that required hospitalizations, i.e. high blood glucose, microcirculation complications, macro-complications of diabetes or other causes.

Unsurprisingly, the proportion of persons hospitalized for diabetes varied by health plan. For persons hospitalized with diabetes in UEBMI (F_1=42.6%; F_2=41.8%). The transition of patients to URBMI was such that the percent of persons with diabetes who were hospitalized was lower in the post-policy period than in the pre-policy change implementation period (F_1=60.4%; F_2=49.4%).

Variable		Prior Policy Change Implementation		
	UEBMI	URBMI	NCMS	Self-Pay
	(n = 1,885)	(n = 229)	(n = 394)	(n = 153)
Demographics				
Age, year	57.7(12.5)	53.9(15.9)	51.6(15.1)	50.1(16.6)
Female, %	42.6	51.1	60.4	42.5
Factors Related to the Costs of Hospitalization for Diabetes 2				
Microcirculation complication, %	76.4	69.0	62.7	60.1
Macro-circulation complication, %	35.6	29.3	21.6	23.5
Length of stay (LOS), day	10.0(4.4)	9.6(3.6)	8.3(3.2)	7.7(3.3)
Total charge, yuan	10,350 (5,279)	9,345(4,032)	8,211(4,912)	7,208 (3,359)
Average daily charge, yuan	1,055 (330)	999 (300)	1,003 (403)	980 (368)

	UEBMI	URBMI	NCMS	Self-Pay
% drug charge as total charge	27.8 (11.7)	24.3 (11.6)	24.9 (11.2)	22.9 (13.1)
% of medical service charge as total charge	14.0 (5.8)	17.1 (6.7)	15.3 (8.8)	15.4 (6.3)
		Post-Policy Change Implementation		
	UEBMI	URBMI	NCMS	Self-Pay
	(n = 2,059)	(n = 704)	(n = 87)	(n =362)
Demographics				
Age, year	58.1(12.4)	54.3(14.5)	51.8(16.6)	53.6(15.9)
Female, %	41.8	58.1	49.4	42.8
Factors Related to the Costs of Hospitalization for Diabetes 2				
Microcirculation complication, %	62.0	53.3	60.9	49.7
Macro-circulation complication, %	30.1	18.9	24.1	16.6
Length of stay (LOS), day	8.3(3.1)	7.9(2.9)	7.2(2.3)	7.4(3.4)
Total charge, yuan	8,240 (4,476)	7,328 (4,120)	6,918 (4,050)	6,820 (4,490)
Average daily charge, yuan	1,003 (376)	947 (349)	984 (425)	930 (385)
% drug charge as total charge	17.9 (10.3)	19.1 (11.1)	14.8 (8.6)	15.7 (9.6)
% of medical service charge as total charge	15.1 (6.1)	16.1 (7.4)	17.3 (6.2)	18.9 (8.0)
Data are expressed as mean and standard deviation (st.d.) unless otherwise indicated. Yuan: the Chinese currency				

Table 1: Participants Demographic and Hospitalization Characteristics (N = 6,102).

As is true in other countries that seek to expand access to health care service via health care policies, the question becomes, "Did the total costs of hospitalizations for diabetes change during the pre- and post-policy change implementation periods?" Hospitalization costs for diabetes in China and elsewhere reflect a number of variables. First, the nature of the diabetes-related hospitalization affects costs. Kattan and Wan [25] identified several factors that are associated with longer lengths of stay (LOS) and/or a higher level of total costs for the hospitalization of persons with diabetes. In addition to demographic variables such as age and other patient characteristics, for example, failure to maintain glycemic control can lead to hospitalization. Thus, both hyperglycemia and hypoglycemia are also associated with hospital readmissions [26]. Similarly, microvascular complications of diabetes and macrovascular complications of diabetes also, via what has been labeled the legacy effects [27] generate consecutively higher hospital costs. Accordingly, an important impact of the policy change implementation process was the degree to which each of the variables were associated with higher total and average daily costs for a diabetes-related hospital stay.

The unadjusted results in Table 1 reveal that hospitalizations for microcirculation complications decreased across all insurance programs except self-pay. Specifically, the decreases were from 76.4% of all diabetes hospitalizations to 68% for UEBMI insured patients - a decrease of -20%. URBMI insured patients hospitalized at the institution used for the study experienced a drop from 69% of all hospitalizations being for microcirculation complications to 53.3% - a decrease of -30%. Although NCMS was going through a process of consolidation, the percent of diabetes Type 2 hospitalizations for micro-complications dropped from 62.7% to 60.9% of all admissions. This was a decrease of -10%. The percent of self-pay patients with microcirculation complications dropped from 60.1% of all hospitalization cases to 49.7%. This was a decrease of -20%,

Except for NCMS, similar decreases occurred for macrocirculation complications (35.6% to 30.1%; 29.3% to 18.9%; 21.6% to 24.1%; and 23.5% to 16.6%, respectively). These changes in the decreased percent of patients treated for both microcirculation and macrocirculation complications suggest that the implementation of the post-policy changes may be reflected

in a shorter length of stay as well as decreased total charges and decreased average daily charges as measured in yuan.

Table 1 confirms that during this same period, increases occurred in the percent of patients who were hospitalized for diabetes at tertiary hospitals. However, these hospitalizations included a lower percent of patients hospitalized for the more expensive microcirculation complications and the extremely expensive macro-circulation complications. As theorized, the length of stay decreased across plans. Thus, it is less than surprising that total charges decreased across plans as did average daily charges. Simultaneously, the before and after changes in the calculations of drug charges as a percent of the total charges in combination with a shift away from treatments for microcirculation and macro-circulation complication was associated with a decrease in drug charges as a percent of total charges. Rather, the percent of total charges paid for medical services increased for all plans except URBMI.

Changes Related to Csosts of Care after Policy Implementation

Table 2 summarizes results of the multivariable analyses related to costs of care after the policy implementation. Significant

decreases occurred in the length of the hospital stay (-1.35 days), total charges per discharge (-540.8 yuan), daily charges (-43.3 yuan), and the percentage of drug charges (-7.85%) across the insurance programs. Meantime, percentage of medical service fees increased by 1.47%. Furthermore, as compared with patients in the UEBMI program, patients in URBMI or self-payer incurred both lower total charges (-346.9 yuan for URBMI patients and -475.1 yuan for self-payer) and lower daily charges (-31.0 yuan for URBMI patients and -35.7 yuan for self-payer). The percentage of drug charges as the total charges were similar among patients in UEBMI, URBMI, and self-pay, but patients in NCMS incurred a lower percent when they were compared to patients in the UEBMI (-1.70%). Finally, in comparison with patients in UEBMI, patients in other insurance programs incurred increases in the percentage of medical services charges (2.44%, 1.58%, and 2.55% increases for patients in URBMI, NCMS, and self-pay, respectively).

As Table 2 demonstrates, the observable increases in health insurance status across plans were statistically significant. As would be expected, the decrease in macro-circulation as causes of the hospitalization experience was significantly associated with the decreases in the length of care.

Variable	Parameter Estimate	Standard Error	p-Value
(1) Length of stay (LOS), day			
Health insurance status			
- UEBMI (reference)	-	-	-
- URBMI	-0.41	0.13	< 0.01
- NCMS	-1.43	0.18	< 0.01
- Self-pay	-1.22	0.17	< 0.01
Policy implementation			
- Before	-	-	-
- After	-1.35	0.10	< 0.01
Age	0.00	0.00	0.45
Sex			
- Female (reference)	-	-	-
- Male	-0.05	0.09	0.56
Complication			
- Microcirculation	0.76	0.10	< 0.01
- Macro-circulation	0.60	0.11	< 0.01
(2) Total charges, in yuan			
Health insurance status			

Variable	Parameter Estimate	Standard Error	p-Value
- UEBMI (reference)	-	-	-
- URBMI	-346.9	131.8	< 0.01
- NCMS	-293.8	176.2	0.10
- Self-pay	-475.1	167.7	< 0.01
Policy			
- Before	-	-	-
- After	-540.8	97.1	< 0.01
Age	30.7	3.8	< 0.01
Sex			
- Female (reference)	-	-	-
- Male	-273.9	93.2	< 0.01
Complication			
- Microcirculation	342.2	102.4	< 0.01
- Macro-circulation	1037.6	108.1	< 0.01
LOS	832.0	12.6	< 0.01
(3) Average daily charges, in yuan			
Health insurance status			
- UEBMI (reference)	-	-	-
- URBMI	-31.0	13.2	0.02
- NCMS	-9.8	17.5	0.57
- Self-pay	-35.7	16.7	0.03
Policy implementation			
- Before	-	-	-
- After	-43.3	9.6	< 0.01
Age	3.8	0.4	< 0.01
Sex			
- Female (reference)	-	-	-
- Male	-17.0	9.3	0.07
Complication			
- Microcirculation	45.7	10.2	< 0.01
- Macro-circulation	89.1	10.8	< 0.01
(4) Percentage of drug charges			
Health insurance status			

Variable	Parameter Estimate	Standard Error	p-Value
- UEBMI (reference)	-	-	-
- URBMI	0.33	0.48	0.49
- NCMS	-1.70	0.36	< 0.01
- Self-pay	-0.35	0.46	0.45
Policy			
- Before	-	-	-
- After	-7.85	0.27	< 0.01
Age	0.18	0.01	< 0.01
Sex			
- Female (reference)	-	-	-
- Male	-0.49	0.26	0.06
Complication			
- Microcirculation	2.58	0.28	< 0.01
- Macro-circulation	3.19	0.30	< 0.01
LOS	0.70	0.03	< 0.01
(5) Percentage of medical service charges			
Health insurance status			
- UEBMI (reference)	-	-	-
- URBMI	2.44	0.30	< 0.01
- NCMS	1.58	0.23	< 0.01
- Self-pay	2.55	0.29	< 0.01
Policy			
- Before	-	-	-
- After	1.47	0.17	< 0.01
Age	-0.09	0.01	< 0.01
Sex			
- Female (reference)	-	-	-
- Male	0.67	0.16	< 0.01
Complication			
- Microcirculation	-2.37	0.18	< 0.01
- Macro-circulation	-0.70	0.18	< 0.01
LOS	0.33	0.02	< 0.01

Table 2: Factors Associated with Cost of Hospital Care for Diabetes.

Changes Related to Clinical Conditions of Hospitalization for Diabetes

Table 3 summarizes main findings related to changes in the odds or likelihood that microcirculation and macrocirculation complications are the clinical conditions for which hospitalization was required. The odds of having a microcirculation complication hospitalization for diabetes was 47% lower (odds ratio (OR) [95% confidence interval (CI)], 0.53 [0.46, 0.60]) after the policy change than before. Similarly, the odds of having a macrocirculation complication if hospitalized for diabetes was 22% lower (OR [CI], 0.78 [0.68, 0.88]) after the policy change than before. Further, as compared with patients in UEBMI, patients in either URBMI or NCMS had comparable likelihoods of having a microcirculation complication whereas self-pay patients were less likely to have a microcirculation complication (OR [CI], 0.79 [0.65, 0.97]).   In contrast, as compared with patients in UEBMI, patients enrolled in URBMI (OR [CI], 0.73 [0.61, 0.88]) and self-pay (OR [CI], 0.63 [0.49, 0.81]) were less likely to have a macro-circulation problem. However, the odds of having a macro-circulation complication were comparable between patients in UEBMI and patients with self-pay.

Health insurance status was also associated with the odds of a macro-circulation. Persons enrolled in URBMI were only 73% as likely to (OR [CII] 0.73 [0.61, 0.88] to be hospitalized for a macro-circulation complication as UEBMI (the reference). This difference in odds was significant (P<0.01). Again, persons insured by NCMS, a health plan that was being phased out, were only 80% as likely. [0.62, 1.02]. This difference in odds ratios was only marginally significant (P<0.07). Those hospitalized under self-pay were only 63% as likely to have a macro-circulation complication [0.49, 0.81] (P<0.01). The odds of a diabetes patient being hospitalized for a macro-complication was only 78% as high after the policy change as before [0.68, 0.88], (P<0.01) when compared with the reference group.

	Odds Ratio	95% Confidence Interval	p-Value
(6) Having microcirculation complication			
Health insurance status			
- UEBMI (reference)	1.00	-	-
- URBMI	0.88	[0.75, 1.04]	0.12
- NCMS	0.92	[0.74, 1.15]	0.45
- Self-pay	0.79	[0.65, 0.97]	0.03
Policy			
- Before	1.00	-	-
- After	0.53	[0.46, 0.60]	< 0.01
Age	1.06	[1.05, 1.06]	< 0.01
Sex			
- Female (reference)	1.00	-	-
- Male	1.23	[1.10, 1.39]	< 0.01
LOS	1.08	[1.06, 1.10]	< 0.01
(7) Having macro-circulation complication			
Health insurance status			
- UEBMI (reference)	1.00	-	-
- URBMI	0.73	[0.61, 0.88]	< 0.01
- NCMS	0.80	[0.62, 1.02]	0.07
- Self-pay	0.63	[0.49, 0.81]	< 0.01
Policy			

	Odds Ratio	95% Confidence Interval	p-Value
- Before	1.00	-	-
- After	0.78	[0.68, 0.88]	< 0.01
Age	1.08	[1.08, 1.09]	< 0.01
Sex			
- Female (reference)	1.00	-	-
- Male	1.24	[1.10, 1.41]	< 0.01
LOS	1.06	[1.04, 1.08]	< 0.01
Yuan: the Chinese currency			

Table 3: Clinical Conditions Associated with Hospitalization for Diabetes.

Discussion

Our results show some policy impact on hospital care for diabetes. One of the interesting findings was the increase in inpatient volume for diabetes hospitalizations at a tertiary hospital after the policy implementation. This outcome alone may indicate that an improvement in access to the top level hospitals in the population occurred for populations who did not have such access under NCMS. One explanation is that the merger of URBMI and NCMS improved benefits and coverage for many former NCMS enrollees. It then became financially feasible for past enrollees to skip the first and secondary hospitals (e.g., township hospitals, county hospitals) to directly go to the tertiary hospitals. Tertiary hospitals can provide higher quality of diabetes and other care. They also have a reputation for excellence. Furthermore, the improvement in ability to pay due to the merger of the insurance programs may have resulted in more patients being able to seek care at tertiary hospitals. It may have also allowed more patients with relatively low acuity of conditions to also go to tertiary hospitals. This explanation is also supported by our other findings that the patients served were less likely to have diabetes-related complications after the policy implementation. However, this finding may have also reflected a lower progression of diabetes because of other health policy change.

Our findings also demonstrate another policy impact. Specifically, after the policy implementation, the length of hospital stay for diabetes was shortened. Additionally, both total charges and daily charges were reduced. While one of the main intentions of the policies was the controlling of costs of care, the study was not designed to uncover causation.

It is of particular importance that the structure of charges for hospital care changed and moved in a more desirable direction after the policy implementation. Specifically, the proportion of total hospital charges associated with prescription drugs decreased while the proportion of labor cost-oriented medical services fees grew. This is a promising outcome for it alters hospital behaviors from using the prescription drug mark-up to ensure the financial viability to increase compensation of those who deliver hospital care - the providers. Historically, physicians, nurses, and other healthcare providers were severely undercompensated by the government in China. The initial health care policies had enforced very low fee schedules for medical services. Because hospitals were unable to generate sufficient revenues through these labor intensive services, they relied on using drug mark-up charges to generate more revenue to offset the financial losses associated with the provision of medical care. As this study revealed, during the post-policy change implementation period, this approach was altered. This change was dually important for hospital care for diabetes because it reduced palliative care and increased medical care. In the pre-policy change period, over-prescription became pervasive. This behavior was called "using drugs to support medical care". The national health policies or, more specifically, the zero mark-up drug pricing policy, tried to reduce over-prescription. It appears, through our findings, that the zero mark-up policy is achieving its goal.

Equally important, our findings revealed that other aspects of the policy change may be interacting to reduce the need for hospitalizations and, as a result, helping to control the cost/charges of hospital care simultaneously. Admissions for diabetes complications decreased thereby shortening length of hospital stay and lowering total charges. This may indicate improvements in both the efficiency and effectiveness of diabetes medical care, throughout the health care pipeline. As discussed, micro- and macro-complications of diabetes typically occur *before* hospitalizations. However, the finding is explained with caution since our data did not tell us that those complications happened before or after the hospital admission. However, medically speaking, complications of diabetes are most likely pre-admission conditions. If this is the

case, our findings indicate that patients with lower acuity were hospitalized after the policy implementation as compared with before the policy implementation.

Finally, if more patients bypass lower level hospitals and go directly to tertiary hospitals with conditions of less acuity, more studies are needed to examine the efficiency of the entire healthcare system which consists of three levels of hospitals. For example, if county and township hospitals are able to treat less severe patients with diabetes, going to tertiary hospitals directly may not be an efficient way of seeking care from the entire healthcare system's perspective. In fact, literature has reported that some township hospitals and county hospitals are financially struggling because they are unable to compete with higher level hospitals in local healthcare markets.

However, the findings from this study may also suggest that there is a need for greater specialization in diabetes care when hospitalization is needed. When macro-circulation complications occur, tertiary hospitals may be better prepared in terms of equipment and personnel to treat such conditioning. This is because conditions such as coronary artery disease, peripheral arterial disease, stroke, etc. require vascular medicine cardiologists, vascular neurologists, and other specialists. Hospitalization or surgery for angioplasty may be required. This surgery may be bypass surgery or thrombolytic therapy or other. The services provided by a tertiary hospital may more closely align with such needs. In contrast, hospitalizations for non-traumatic limb amputations, emergencies associated with chronic kidney disease and other microcirculation emergencies that require hospitalization may, depending upon severity be treated at township hospitals. Furthermore, diabetic emergencies that require hospitalization such as diabetic ketoacidosis, hyperosmolar hyperglycemic states, and other hyperglycemic and/or hypoglycemic conditions can be easily treated at county hospitals. Again, the findings from this study implies a need for further research to determine whether the three levels of hospitals in China can reduce costs and improve care by specializing in the different types of hospitalization emergencies that sometimes accompany diabetes.

In addition to the clinical questions raised by our findings, the study demonstrated the savings in total charges, average daily charges, and the drug charges as a percent of total charges that occurred in the post-health policy change implementation period relative to the pre-implementation period. This suggests that the "supply-side" policy changes that are associated with these successes may require supplementation by additional "demand-side" strategies that result in earlier diagnosis of diabetes, strategies to reduce the progression from pre-diabetes, and other interventions to further elevate patient self-management and physician-management of Type 2 diabetes patients. Such a holistic approach will further decrease the percent of all-cause

hospitalizations for diabetes in China.

The morbidity rate is 20.2% among adults aged 60 years or older with type 2 diabetes in China, and is about twice that of all adult population [28]. They are always known as the population of frail older adults associated with functional disability, several comorbidities, and premature mortality. The therapeutic options for elderly patients with diabetes must be carefully prescribed and monitored, according to the patient cognitive capacities, the potentially drug-drug interactions, and the cardiovascular and hypoglycemia risk. The older adults with diabetes are special population whose disease control influences the overall outcomes of diabetes. Close attention should be paid to senior patients with diabetes in regard to improving their disease management and outcomes.

This study had limitations. First, we were unable to differentiate the effect of the merger of URBMI and NCMS from the effect of the zero mark-up drug pricing policy. Nevertheless, positive impacts from the implementation of both policies were observed on hospital care for diabetes. For example, changes supportive of improved care occurred in the percentage of drug charges and the percentage of medical service charges. Second, given that the data used was from one healthcare facility, the finding may not be generalizable to hospitals in general. Nevertheless, the study does provide empirical evidence regarding improvements in efficiency and effectiveness of hospital care under the recently implemented healthcare reforms in China. Third, the study only focused on diabetes with limited outcome measures. Future research is needed that examines the policy impact on other diabetes-related outcomes (e.g., gangrene, limb amputation: not available in our dataset) or other diseases.

Conclusions

As alluded to in this paper, China is in the midst of explosive growth in the number and percent of its residents who are vulnerable to Type 2 diabetes mellitus. As a result, the overall health care reform that has continued over several years has had an impact upon access to health care for this disease, costs of health care, and health care outcomes. Evidence is needed regarding the efficacy of policy reforms implementations regarding this widespread health chronicity. This study provides evidence that the implementation of at least a limited number of these changes at a large tertiary hospital in northern China had positive results.

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