

BMJ Open Prevalence and temporal pattern of hospital readmissions for patients with type I and type II diabetes

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ABSTRACT

Objective: Repeated hospitalisation for patients is common and costly, yet partly preventable. However, we know little about readmissions for patients with diabetes in China. The current study aims to assess the frequency and temporal pattern of and risk factors for all-cause readmission among hospitalised patients with diabetes in Tianjin, China.

Method: This retrospective, cohort analysis used the Tianjin Basic Medical Insurance Register System data of 2011. The patterns of and the reasons for all-cause readmissions for patients with diabetes were described. The differences of readmission-free survival (RFS) between newly and previously diagnosed patients were compared. Time-dependent Cox models were established to identify the risk factors for readmission at different time intervals after discharge.

Results: Readmission rates were approximately 30%, with the most common diagnoses of cerebral infarction (for type I) or diabetes (for type II) for patients with diabetes. The majority of patients were readmitted to the hospital after more than 90 days, followed by 8–30 days (all $p=0.002$). Approximately 37.2% and 42.8% of readmitted patients with type I and type II diabetes were diagnosed previously, and the RFS rates for previously diagnosed patients were significantly lower than for newly diagnosed patients at any time interval after discharge. Prior history of diabetes (all $p<0.05$), length of stay (all $p<0.01$) and reimbursement ratio (90% vs >92%, all $p<0.0002$) were consistently associated with the RFS for patients readmitted to the hospital at <7, 8–30, 31–60 and 61–90 days.

Conclusions: Hospital readmissions among patients with diabetes were affected by the diagnosis status. Patient characteristics and the quality of healthcare might regulate short-interval and long-interval hospital readmission, respectively, after discharge.

INTRODUCTION

Currently, China has the largest population with diabetes among the developing nations.¹ The prevalence ranges from 8.3% to 12.7% with geographical variation, and one-third of patients are living with previously undiagnosed diabetes.² In China, the direct medical cost of diabetes-related

Strengths and limitations of this study

- This is, to the best of our knowledge, the first study to discover the prevalence and temporal pattern of and the factors for readmission for patients with type I and type II diabetes in China.
- We used the time-dependent Cox proportional hazards model to assess the impact factors for readmissions, taking into account the fact that the response variable changes over time.
- We found that patients who were discharged with previously diagnosed diabetes consistently have lower readmission-free survival and that short-interval and long-interval readmission after discharge might be driven by different factors.
- Some extra elements, such as socioeconomic status of patients and more detailed information of their disease conditions, may contribute to readmissions, but these data were unavailable in the current study.
- This study used administrative data, which are not always adequate and accurate for patient information. As a consequence, we could not distinguish type I and type II diabetes perfectly and could not assess readmission in the areas of transition of care and outpatient care.

disorders was estimated at US\$26.0 billion in 2007, and costs are expected to increase to \$47.2 billion by 2030,³ much of which is due to the usage of in-hospital services.^{4–7} Inpatient management of patients with diabetes is often less than optimal, and suboptimal management is associated with excess mortality, increased length of stay and increased odds of readmission for discharged patients.^{8–10} Diabetes has been previously cited as one of the diseases for which readmissions are likely to be a valid measure of the quality of care in developed countries.⁸ Putting the necessity of awareness aside, readmissions for patients with diabetes are preventable,¹¹ especially for older patients, if these patients comply with effective drug treatment, receive adequate post-discharge care and control the progression of the basic

disease.¹² These steps can only be realised through the cooperation of patients, hospitals and public health as a whole.¹³ Therefore, reducing readmission should become a policy focus because it represents an opportunity to improve quality and reduce healthcare costs simultaneously, yet little is known about the profile of readmission for patients with diabetes in China.

Beyond simply describing the current situation, there is an increasing urgency to determine the influencing factors. Previous studies indicated that readmission is primarily driven by the use of health resources of communities where hospitals are located,¹⁴ hospitals' performance,¹⁵ coexisting conditions of a patient^{14 15} and different types of medical insurance.¹⁶ Notably, another possibility is diagnosis status, namely 'newly' or 'previously' diagnosed. Studies have proven that the longer the duration of diabetes, the worse the prognosis of the patient,⁹ because a history of diabetes is associated with high risk of morbidity and mortality for related disorders.^{17–20} However, we are unaware of prior work on the hazards of readmission for patients with diabetes.

The city of Tianjin is located in the eastern coastal area of China, where the prevalence of diabetes is the highest. It is the third largest city, and its political status is equal to that of the provinces. In this region, the positive rate of high blood sugar screening has been assessed to be 12%,² which approaches the peak of diabetes prevalence in China. Hence, in this area, the opportunity for evaluating the profile of readmission for patients with diabetes is unique. In understanding the prevalence of and risks for readmission, and recognising who is more vulnerable, publicly reported conditions can help improve the design of interventions that target the proper subjects and healthcare facilities. In this study, we report the prevalence of readmission for patients with diabetes in Tianjin, China, discover the frequent medical reasons for readmission and determine whether readmission is associated with diagnosis status. By establishing the Time-to-Event proportional risk model, we estimated the HR for patients with either type I or type II diabetes readmitted to the hospital within a year and within 7, 8–30, 31–60, 61–90 and >90 days between the index discharge and the next hospitalisation. We aimed to provide insights into the possible impact factors of readmission and shed light on the areas where interventions can lead to better medical services and lower costs.

MATERIALS AND METHODS

Data and studied population

We created a retrospective cohort using the Tianjin Basic Medical Insurance Register System (TBMIRS) database to identify all records of hospitalisations with discharge diagnoses of diabetes between 1 January 2011 and 30 December 2011 in Tianjin, China, for Basic Medical Insurance (BMI) beneficiaries (International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10) codes for diabetes, E10-E14).

Since 2009, the coverage rate of BMI has been >90%; thus, TBMIRS can identify almost all residents in Tianjin.²¹ We used a randomised stratified sampling method, selecting 50% of these records as a sample. We were able to ascertain each patient's exclusive personal code, age, sex and clinical diagnoses, and to gather information on the characteristics of hospitals where the patient was admitted. We excluded patients who were transferred to other hospitals on the day of discharge and patients who were discharged on the day of admission. Only patients surviving to discharge were included. Our final sample consisted of 62 746 discharges of 37 620 patients; among them, 16 548 were discharged with type I diabetes and 21 072 were discharged with type II diabetes. All patient records and information were anonymised and de-identified prior to analysis.

Assessment of hospital readmission and definitions of variables

We defined patients with multiple hospitalisation records as readmission patients; other patients were defined as readmission-free patients. The rates of readmission were defined as: the number of patients discharged from any recorded hospital and readmitted with any medical reason to any recorded hospital within 7, 8–30, 31–60, 61–90 or >90 days, divided by the total number of patients who were discharged alive from recorded hospitals. To identify the most vulnerable patients for readmission, patients were categorised as those with either previously or newly diagnosed diabetes. Previously diagnosed patients were those with a prior history of diabetes and were defined as those who had any previous usage of diabetes-related medical services (in pharmacies, as outpatients or in hospitals) in the 1-year period before the index hospitalisation. Patients who had no diabetes-related claims in the 1-year period before the index hospitalisation were categorised as newly diagnosed with diabetes.

To examine the primary reasons for readmission at discharge, we identified the top five most frequent diagnoses based on ICD-10 and tabulated them for readmission by year and by five time intervals after discharge for each type of diabetes. We also tabulated patient demographic characteristics, including age, sex and employment status (employed or retired); patient clinical characteristics, including presence or absence of diabetes-related complications and other comorbidities, such as primary hypertension (PH), congestive heart failure (CHF) and infectious diseases (IDs, including hepatitis, sexually transmitted diseases, tuberculosis, typhoid and dysentery), with or without an operation during the index hospitalisation, and the length of stay; and the reimbursement ratio of healthcare costs, which represents the portion of hospitalisation costs for which the patient will be reimbursed and is tailored for patients each time they visit a healthcare facility. We also analysed the hospital-based characteristics, which present a dividing line to distinguish hospital quality

levels in China. According to the Ministry of Public Health of China, the hospitals (or clinics) that only provide primary healthcare services to a specific local community and contain <100 beds are defined as primary hospitals. Secondary hospitals provide primary healthcare services to more than one local community, serve as teaching and research hospitals, and are equipped with no <101 beds. Tertiary hospitals are equipped with more than 501 beds, can provide highly professionalised health services without regional boundary limitations, have the ability to train advanced professionals and conduct scientific research independently. Finally, the median direct medical costs of index hospitalisation were reported between groups.

Statistical analysis

We first used χ^2 test, Fisher's exact test or Wilcoxon test to compare the characteristics of patients and hospitals between readmission and readmission-free groups for each type of diabetes. The comparison of readmission rates at different time intervals between newly and previously diagnosed patients with diabetes was performed by χ^2 test for each type of diabetes. Log-rank test were used to compare the different survival rates between patients with newly and previously diagnosed diabetes.

We used the time-dependent Cox proportional hazards model to assess the impact of a previous diagnosis of diabetes on 1-year readmissions and readmissions within 7, 8–30, 31–60 and 61–90 days. The proportional hazards model is usually expressed in terms of a single survival time value for each person, with possible censoring. Andersen and Gill reformulated the same problem as a counting process.²² The data for a subject are presented as multiple 'observations', each of which applies to an interval of observation (start, stop). The day of discharge for an index hospitalisation was the start time, and the day of readmission after discharge was the stop time. Data were censored at the end of the observation period (eg, 7, 30 or 60 days). Covariates were the patients' and hospitals' characteristics, including age, sex, employment status, type of diabetes, length of stay, presence or absence of diabetes-related complications (diabetic ketoacidosis, non-ketotic hyperosmolar coma, diabetic cardiomyopathy, diabetic nephropathy, diabetic neuropathy, diabetic retinopathy, diabetic myonecrosis and diabetic foot), HP, CHF and ID, with or without any operation during the index hospitalisation, hospital grade where the patient was admitted at the index hospitalisation and the reimbursement ratio of healthcare costs for each subject.

All reported *p* values are two sided. All analyses were conducted with R software (V.3.3.1.).

Validity and sensitivity analysis

To assess the stability of the built model at the baseline scenario, we performed a sensitivity analysis based on a computer-intensive resampling bootstrap method. The mean of coefficients ($\hat{\theta}_i$) for variables was estimated

from 1000 testing models, and these models were established using the data of 1000 times repeated sampling with replacement of the baseline records. The baseline model is considered as a stable model if the estimated mean coefficients quantifiably approximated the coefficients in the baseline model. And the variances between the values were acceptable: for each estimated coefficient, $(|\hat{\theta}_i - \hat{\beta}_i| / \widehat{S}_{\theta_i}) \times 100\%$ is smaller than 25%.²³ Since there was no standard for distinguishing unplanned readmissions, we performed a sensitivity analysis by repeating our 1-year readmission model but excluded patients with a diagnosis of any type of cancer or with chemotherapy, radiotherapy or biotherapy treatment during the index hospitalisation. As another sensitivity analysis, we evaluated the discrimination of our model. We created Kaplan-Meier (KM) survival curves for predicted risk groups that were separated based on the predicted HRs. These HRs were calculated through the baseline 1-year readmission model. The more widely separated the curves, the better the model discrimination.²⁴

RESULTS

From our final sample, we excluded 1486 patients who were transferred on the day of discharge or discharged on the same day of admission. Of the 37 620 patients in our sample, 16 548 and 21 072 were diagnosed with type I and type II diabetes, respectively, and 29.8% of the patients with type I diabetes and 29.0% of the patients with type II diabetes were hospitalised more than once (table 1). For type I diabetes, compared with readmission-free patients, the readmitted patients were older, more often male, retired, and more likely to have PH and CHF; they also had longer lengths of stay and higher reimbursement ratios, and were more often admitted to lower grade hospitals. Significantly lower median costs for index hospitalisation were found for readmitted patients compared with those for readmission-free patients. These characteristics were similar to those for patients with type II diabetes, except that the readmitted patients were more likely to have diabetes-related complications and ID; no significant difference for gender or operation status was found between groups.

Most patients were readmitted to the hospital at more than 90 days after the index discharges, followed by within 8–30 days. A total of 4925 patients with type I diabetes were readmitted to hospital in 2011, and 37.2% were diagnosed previously. A total of 6115 patients with type II diabetes were readmitted to hospital in the same year, and 42.8% were diagnosed previously. Figure 1 shows that, for both types of diabetes, the proportions of readmission for previously diagnosed patients with diabetes were higher than for newly diagnosed patients at 31–60, 61–90 and >90 days (*p*=0.002).

Table 2 shows the five most frequent medical reasons for readmission. The most frequent primary diagnoses

Table 1 Discharge characteristics by type of diabetes

Variables	Patients with type I diabetes (N=16 548)		Patients with type II diabetes (N=21 072)		p Value*	p Value**
	Readmission free	Readmission	Readmission free	Readmission		
Age	62.3 (11.9)	64.2 (11.1)	62.7 (11.5)	66.0 (10.7)	<0.0001	<0.0001
Gender						
Male	6532 (56.2)	2683 (54.5)	8116 (54.3)	3251 (53.2)	0.043	0.151
Female	5091 (43.8)	2242 (45.5)	6841 (45.7)	2864 (46.8)		
Employment status						
Yes	2860 (24.6)	897 (18.2)	3440 (23.0)	851 (13.9)	<0.0001	<0.0001
No	8763 (75.4)	4028 (81.8)	11 517 (77.0)	5264 (86.1)		
Previously diagnosed diabetes						
Yes	2539 (21.8)	1833 (37.2)	3901 (26.1)	2615 (42.8)	<0.0001	<0.0001
No	9084 (78.2)	3092 (62.8)	11 056 (73.9)	3500 (57.2)		
With complications						
Yes	1824 (15.7)	807 (16.4)	3727 (24.9)	1633 (26.7)	0.2753	0.007
No	9799 (84.3)	4118 (83.6)	11 230 (75.1)	4482 (73.3)		
With primary hypertension						
Yes	6901 (59.4)	3042 (61.8)	9488 (63.4)	4386 (71.7)	0.004	<0.0001
No	4722 (40.6)	1883 (38.2)	5469 (36.6)	1729 (28.3)		
With congestive heart failure						
Yes	333 (2.9)	173 (3.5)	537 (3.6)	360 (5.9)	0.027	<0.0001
No	11 290 (97.1)	4752 (96.5)	14 420 (96.4)	5755 (94.1)		
With infectious diseases						
Yes	296 (2.5)	133 (2.5)	371 (2.5)	207 (3.4)	0.5691	0.0003
No	11 327 (97.5)	4792 (97.2)	14 586 (97.5)	5908 (96.6)		
With index operation						
Yes	3178 (27.3)	1019 (20.6)	2020 (13.5)	806 (13.2)	<0.0001	0.5302
No	8445 (72.7)	3906 (79.3)	12 937 (86.5)	5309 (86.8)		
The length of stays	12.7 (8.3)	13.3 (8.4)	12.9 (6.5)	13.9 (7.3)	<0.0001	<0.0001
Reimbursement ratio, %						
>92	182 (1.8)	401 (8.2)	312 (2.0)	679 (11.1)	<0.0001	<0.0001
90	8581 (73.8)	3629 (73.7)	11 211 (75.0)	4586 (75.0)		
85	2860 (24.6)	895 (18.2)	3434 (23.0)	850 (13.9)		
Hospital grades						
First	969 (8.2)	637 (12.9)	1029 (6.9)	872 (14.3)	<0.0001	<0.0001
Second	3333 (28.7)	1507 (30.6)	3881 (25.9)	1684 (27.5)		
Third	7321 (63.0)	2781 (56.5)	10 047 (67.2)	3559 (58.2)		
Costs for index hospitalisation	9350.9 (9050.2)	9184.4 (9678.4)	8643.7 (5998.5)	8589.1 (7240.8)	<0.0001	0.0002

p*: the comparisons between readmission and readmission-free patients with type I diabetes; p**: the comparisons between readmission and readmission-free patients with type II diabetes. p Values were generated using χ^2 and Fisher's exact tests for categorical variables and using Wilcoxon test for continuous variables.

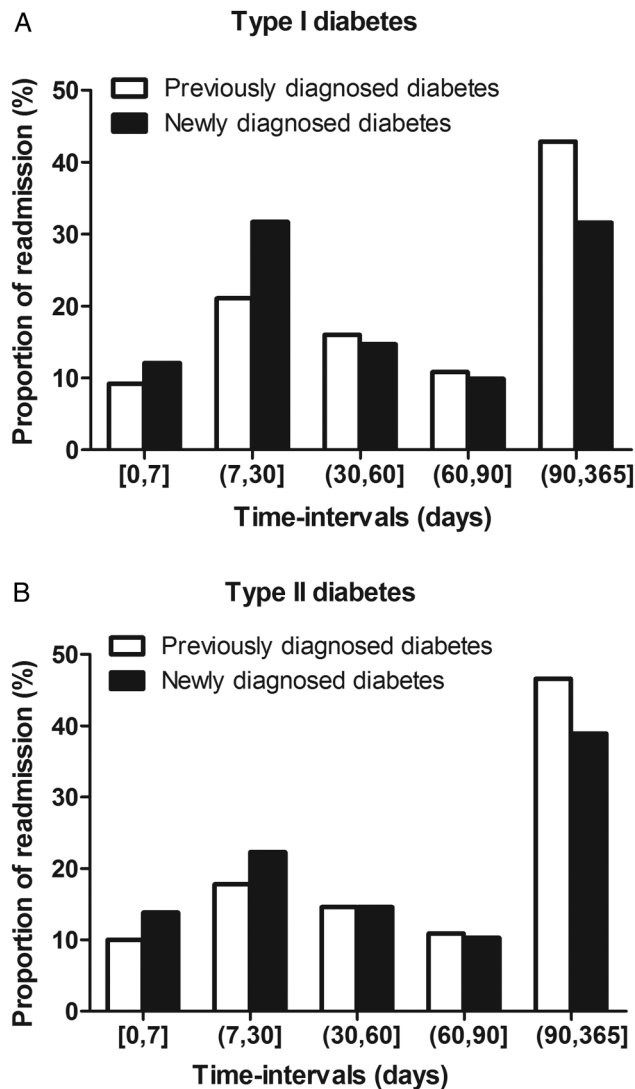


Figure 1 The proportions of readmission for newly and previously diagnosed patients with diabetes showed that, for both type of diabetes, the proportions of readmission for previously diagnosed patients with diabetes were higher than for newly diagnosed patients at intervals of 31–60, 61–90 and >90 days ($p=0.002$).

were cerebral infarction (14%) and diabetes (16.5%) for patients with type I and type II diabetes, respectively, which were the same at each time interval. Malignant neoplasm of the breast, bronchus and lung, as well as unspecified heart disease, were also frequent diagnoses for 1-year readmission for patients with type I diabetes. For patients with type II diabetes, the reasons for readmission at each time interval were almost similar to those for 1-year readmission.

We found that the overall 1-year readmission-free survival (RFS) rates of patients with previously diagnosed diabetes were significantly lower than those of newly diagnosed patients (figure 2): 0.67 (0.65–0.68) versus 0.79 (0.78–0.79) for type I diabetes and 0.70 (0.69–0.72) versus 0.81 (0.81–0.82) for type II diabetes. This difference was also found for cumulative

RFS rates at all intervals after discharge (table 3, all $p<0.0001$).

Multivariate time-dependent Cox proportional hazard regression analyses were used to evaluate the independent impact factors associated with patients' 1-year RFS and RFS at different time intervals after discharge. Online supplementary table S1 shows that a prior history of diabetes was an independent factor associated with 1-year RFS and RFS at any time interval after discharge. The HRs were 1.15 (95% CI 1.01 to 1.29, $p=0.03$), 1.15 (95% CI 1.05 to 1.25, $p=0.0017$), 1.52 (95% CI 1.37 to 1.68, $p<0.0001$) and 1.69 (95% CI 1.50 to 1.90, $p<0.0001$) for patients readmitted to the hospital within 7, 8–30, 31–60 and 61–90 days, respectively, along with HR 1.44 (95% CI 1.38 to 1.50, $p<0.0001$) for 1-year readmission. Overall, patients who were older (HR 1.01, 95% CI 1.00 to 1.01, $p<0.0001$), admitted to a primary hospital (HR 0.91, 95% CI 0.85 to 0.97, $p=0.0053$ and HR 0.87, 95% CI 0.81 to 0.93, $p<0.0001$ for readmission in secondary and tertiary hospitals, respectively, compared to that in primary hospitals, which had a reference HR of 1), diagnosed with type II diabetes (HR 0.92, 95% CI 0.89 to 0.96, $p<0.0001$ for patients with type I diabetes), diagnosed with PH (HR 1.07, 95% CI 1.03 to 1.12, $p=0.001$), CHF (HR 1.16, 95% CI 1.06 to 1.27, $p=0.0009$), or diagnosed with ID (HR 1.29, 95% CI 1.16 to 1.44, $p<0.0001$) had higher HR for readmission. Patients who experienced longer stays and those who had higher reimbursement ratios of healthcare costs at index hospitalisation consistently had a higher HR of readmission at all time intervals.

Following examination of readmission at each time interval after discharge, the impact factors we found were not consistent. For example, the type of diabetes did not have an impact on 61–90 days of readmission ($p=0.492$) and having an operation at index hospitalisation was only associated with a relatively earlier phase of readmission (within 30 days). Notably, the comorbidity of PH had contradictory impacts on RFS; it was a risk factor for 7, 61–90 days and 1-year RFS but a protective factor for RFS within 8–30 days.

The results of the stability evaluation for the baseline model showed that each estimated mean coefficient ($\hat{\theta}_i$) was substantially stable and similar to that estimated from the baseline model. Meanwhile, all $(|\hat{\theta}_i - \hat{\beta}_i| / \hat{S}_{\theta_i})\%$ were smaller than 25%, which means that the baseline 1-year readmission model was highly stable (see online supplementary table S2).

Analyses that excluded patients with a discharge diagnosis of any type of cancer or with a treatment of chemotherapy, radiotherapy or biotherapy did not significantly change our results; the specific HRs were qualitatively similar to those of the baseline 1-year readmission model (see online supplementary table S3). Figure 3 shows the KM-survival curves for RFS as predicted in the baseline model from the HRs. The two curves are well separated, confirming that our model has good discrimination.

Table 2 Most frequent diagnoses for readmission for patients with diabetes by diagnose status and type of diabetes

Time intervals after discharges	Most frequent	Second most frequent	Third most frequent	Fourth most frequent	Fifth most frequent
For type I diabetes					
0–7 days	Cerebral infarction (21.4%)	Chronic ischaemic heart disease (5.0%)	Acute ischaemic heart disease (3.9%)	Polyneuropathy in diseases (3.7%)	Ill-defined descriptions of heart disease (3.5%)
8–30 days	Cerebral infarction (8%)	Malignant neoplasm of breast (6.9%)	Malignant neoplasm of bronchus and lung (6.4%)	Chronic ischaemic heart disease (4.2%)	Diabetes (4.2%)
31–60 days	Cerebral infarction (10.5%)	Diabetes (6.9%)	Chronic ischaemic heart disease (5.5%)	Acute ischaemic heart disease (5.5%)	Malignant neoplasm of bronchus and lung (2.9%)
61–90 days	Cerebral infarction (14.1%)	Heart disease, unspecified (7.0%)	Chronic ischaemic heart disease (6.4%)	Acute ischaemic heart disease (4.6%)	Diabetes (3.8%)
>90 days	Cerebral infarction (15.1%)	Chronic ischemic heart disease (7.1%)	Polyneuropathy in diseases (5.2%)	Acute ischaemic heart disease (5.2%)	Diabetes (4.5%)
1 year	Cerebral infarction (14%)	Chronic ischaemic heart disease (5.8%)	Diabetes (4.5%)	Acute ischaemic heart disease (4.3%)	Polyneuropathy in diseases (3.3%)
For type II diabetes					
0–7 days	Diabetes (17.5%)	Cerebral infarction (16.6%)	Chronic ischaemic heart disease (9.9%)	Ill-defined descriptions of heart disease (2.9%)	Pneumonia (2.9%)
7–30 days	Diabetes (17.3%)	Cerebral infarction (11.3%)	Chronic ischaemic heart disease (9.1%)	Ill-defined descriptions of heart disease (2.6%)	Pneumonia (2.5%)
30–60 days	Diabetes (16.7%)	Chronic ischaemic heart disease (9.0%)	Cerebral infarction (8.6%)	Ill-defined descriptions of heart disease (3.4%)	Pneumonia (2.4%)
60–90 days	Diabetes (20.9%)	Cerebral infarction (11.5%)	Chronic ischaemic heart disease (8.5%)	Ill-defined descriptions of heart disease (3.9%)	Pneumonia (2.9%)
>90 days	Diabetes (29.9%)	Cerebral infarction (11.9%)	Chronic ischaemic heart disease (8.2%)	Polyneuropathy in diseases (2.6%)	Ill-defined descriptions of heart disease (2.6%)
1 year	Diabetes (16.5%)	Cerebral infarction (11.7%)	Chronic ischaemic heart disease (8.7%)	Ill-defined descriptions of heart disease (2.9%)	Pneumonia (2.5%)

The International Classification of Diseases, Tenth Revision (ICD-10) codes for conditions are as follows: cerebral infarction: I63; diabetes: E11; chronic ischaemic heart disease: I25.1; malignant neoplasm of breast: C50; malignant neoplasm of bronchus and lung: C34; polyneuropathy in diseases: G63.2; acute ischaemic heart diseases: I24; ill-defined descriptions of heart disease: I51.9; chronic ischaemic heart disease: I63.9; pneumonia: J18.9.

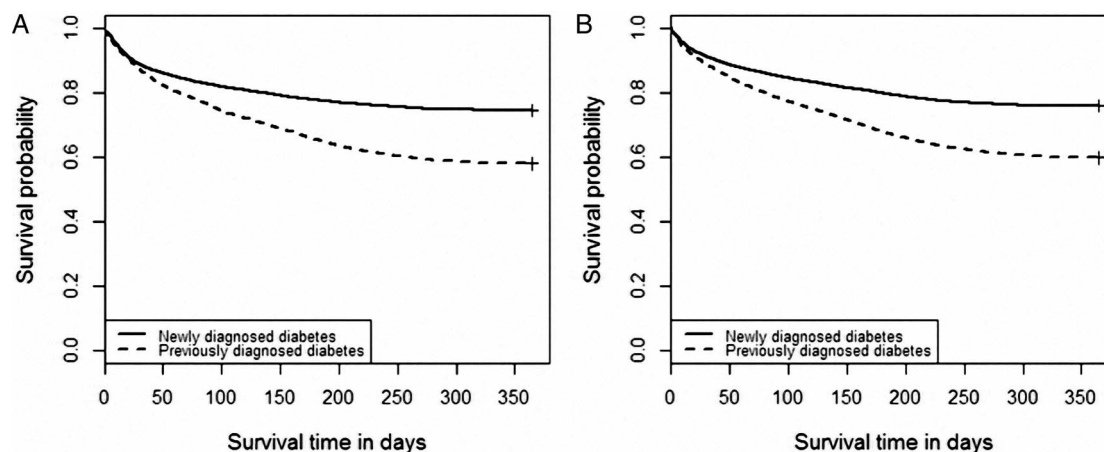


Figure 2 Kaplan–Meier (KM)-survival curves for readmission-free survival (RFS) of patients with (A) type I and (B) type II diabetes by diagnosis status. The 1-year RFS rate of patients with previously diagnosed type I or type II diabetes was significantly lower than that of newly diagnosed patients ($p < 0.0001$).

DISCUSSION

Our previous study suggested that increased medical costs might partly be driven by the repeated use of hospital resources,²⁵ especially for chronic diseases. Therefore, controlling hospital readmission may help to balance the quality of healthcare services and healthcare costs. However, evaluating the profile of hospital readmission has not captured the attention of China's policymakers. This might be because no potential impact factor of readmission has been recorded, evaluated or reported, such as the quality of hospital services and patients' discharge orientations.²¹

In the current study, we uncovered the prevalence of hospital readmission for patients with type I and type II diabetes and objectively assessed the potential impact factors. We have several notable findings: approximately 30% of patients with diabetic have had multiple hospitalisations, and cerebral infarction (for type I) and diabetes (for type II) were the most frequent reasons for hospital readmission. Consistent with the results of previous studies,²⁶ the majority of patients were readmitted within 30 days (including the patients who were readmitted within 7 days), apart from those who were

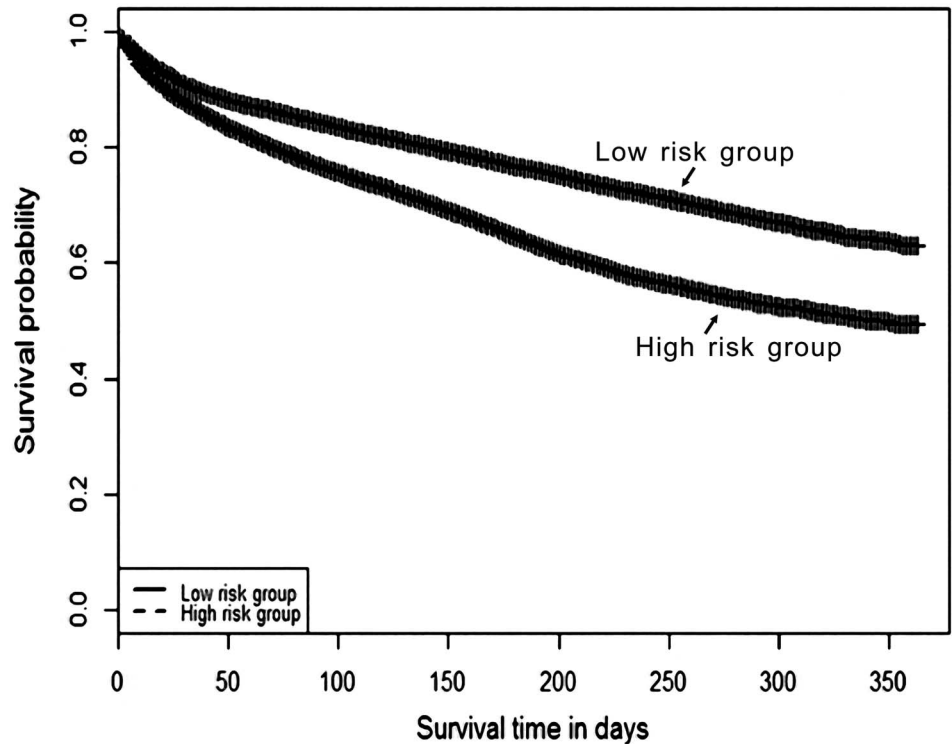
readmitted outside of 90 days after discharge. A prior history of diabetes was an independent risk factor for 1-year RFS and for RFS at any time interval after discharge.

We found that the proportion of readmission for patients with either type I or type II diabetes in China was much higher than in developed countries and also higher than the readmission rates for patients with any disease in developed countries,^{8 26 27} which indicates a substantial burden on both patients and the healthcare system in China. Generally, cardiovascular disease (CVD), cerebrovascular diseases (CeVDs), polyneuropathy diseases and some specific cancers, along with hyperglycaemia, were the main causes for patients with diabetes being readmitted to hospitals after the index discharge. Hyperglycaemia is a major risk factor for CVD (including cerebral infarction) and CeVDs,^{28–31} which have become leading causes of death in China,²⁸ and the development of complications of diabetes has also been related to glucose levels.^{32 33} Therefore, using hospital-wide interventions to reinforce glycaemic control might be an effective approach to control disease-related readmission.^{34–36} It is unclear why

Table 3 The cumulative readmission-free survival rates between newly and previously diagnosed diabetes within time intervals by type of diabetes

Time intervals after discharges	Newly diagnosed diabetes	Previously diagnosed diabetes	p Value
For type I diabetes			
30 days	0.93 (0.93–0.93)	0.92 (0.91–0.93)	<0.0001
60 days	0.89 (0.88–0.89)	0.87 (0.86–0.88)	<0.0001
90 days	0.87 (0.86–0.87)	0.83 (0.83–0.84)	<0.0001
1 year	0.78 (0.78–0.79)	0.67 (0.65–0.68)	<0.0001
For type II diabetes			
30 days	0.94 (0.94–0.94)	0.93 (0.92–0.9)	<0.0001
60 days	0.91 (0.91–0.92)	0.89 (0.88–0.90)	<0.0001
90 days	0.89 (0.89–0.90)	0.86 (0.85–0.87)	<0.0001
1 year	0.81 (0.81–0.82)	0.70 (0.69–0.73)	<0.0001

Figure 3 KM-survival curves for readmission-free survival (RFS) of patients with diabetes by predicted risk groups. The KM-survival curves for RFS as predicted in baseline 1-year readmission model from the HRs. Two curves represented low-risk group (upper) and high-risk group (lower) for readmission, respectively, and were well separated, confirming our model has good discrimination.



patients discharged with different subtypes of diabetes would have different primary reasons for readmission. For example, the most frequent primary diagnoses were cerebral infarction for patients with type I and type II diabetes. To the best of our knowledge, few studies have compared the differences of disease progression in patients with different subtypes of diabetes, and further investigation of this possibility is warranted. Although the conditions for readmission for patients with a specific subtype of diabetes were relatively consistent at different time intervals, the diagnoses we used relied on the ICD-10 rather than on diagnose-related groups, which might cause difficulty in disease clustering. Thus, we cannot rule out the possibility that some underlying reasons for readmission might not have been discovered.

Finding a suitable time window to implement interventions has continually induced debate³⁷; some studies indicated that readmission occurring within a short interval after discharge was affected by the quality of inpatient services and post-discharge follow-ups, whereas readmission at a long interval was explained more by the case mix of the patient.^{37 38} The within 30 days readmission rate has been used by the governments of the USA, Canada, Australia, the UK and New Zealand, to assess the quality of healthcare services.^{27 39–42} One of the primary reasons is the large amount of patients readmitted within this interval, which is similar to our result of relatively high rates of readmission being found within 30 days for both types of diabetes. The feasibility of implementing interventions at this interval in China needs to be addressed in the future.

When we considered the cumulative RFS of patients with diabetes for a year, a stable decreased tendency was

found. Despite the ongoing interest in understanding readmission internationally, much of the previous work has focused on the differential outcomes between groups, such as the case mix of patients, or on the performance of the healthcare system,^{14 15 27 43–46} without taking diagnosis status into account, which is strongly associated with the prognosis of chronic diseases, especially for patients with diabetes. Cakir *et al*⁴⁷ found that newly diagnosed patients (the majority of whom might have been previously undiagnosed patients) were more likely to have worse prognosis, which is worthy of attention because a large number of patients in China live with undiscovered diabetes.^{1 48–50} We speculated that these undiscovered patients would have flowed into the pool of diagnosed patients and have appeared as ‘newly’ onset patients after the recent implementation of mass screening for chronic diseases in urban communities of Tianjin.⁵¹ The screening was launched in 2009 and was motivated by Health System Reform (HSR) in China, which regards controlling the epidemic of chronic disease as a priority.²¹ However, we found that the associations of hazard of readmission with prior history of diabetes were consistent (for 1-year readmission and the readmission at each time interval), suggesting that the history of diabetes is, at least in part, as important as case mix and hospitals’ performances in the RFS for patients with diabetes. Our results indicated that a relatively longer duration of diabetes increased the likelihood of poor prognosis and simultaneously suggested that the ‘newly diagnosed’ patients in Tianjin did not consist of all of the ‘previously undiagnosed’ patients, and that the screening in Tianjin cannot reveal all undiagnosed patients.

The factors responsible for readmissions were different at different time intervals, suggesting that the underlying reasons for readmission might also be different at different time intervals between two hospitalisations. We found that the case mix has more impact on the HR of 7-day readmission than on the HR of readmission at other intervals because the comorbidity of PH, CHF and ID simultaneously impacted 7-day readmission but not readmission at other intervals. In contrast, no impact of hospital grade was found on 7-day readmission, but there was an impact on 90-day readmission. That is, admission to a secondary or a tertiary hospital at index hospitalisation was a protective factor for RFS at a longer interval. Since high-grade hospitals represent greater ability of providing healthcare in China, we assumed that readmission occurring within 7 days after discharge might be associated more with patient characteristics and that readmissions occurring within a longer interval, perhaps 90 days, might be affected more by the provided healthcare. Further studies are needed to verify our assumption, such as to evaluate the association between the quality of hospital performances and hospital readmission rates.

We found that the comorbidity of PH acted as a protective factor for RFS within 8–30 days after discharge. Others have examined the role of PH in determining patient outcomes. For example, for Medicare patients with acute myocardial infarction, PH played a protective role for within 30 days mortality but a risk role for within 30, 60 and 90 days readmission.^{43 52} Heart failure patients with PH have a lower risk for within 30 days readmission.⁴⁴ These results can be explained by factors that are related to the management of chronic diseases. Patients with diabetes with PH might receive closer management, which is effective for reducing the likelihood of short-term prognostic risks. This effect was not observed for within 7 days readmission, due to the complexity of patients' case mixes. This issue should be better understood before interventions are implemented.

Previous studies have proven that patients who were covered by different types of insurances might have different motivations to seek inpatient services, and this is potentially affected by different reimbursement strategies.^{16 53} The reimbursement rules of BMI were formulated by considering resident areas (urban or rural), healthcare costs and identities of the beneficiaries (general workers or model workers) as a whole. We found that patients with a >92% reimbursement ratio have a higher HR for readmission compared to those with a 90% reimbursement rate at all intervals after discharge after adjusting for patients' age, employment status, disease conditions and the hospitals' grades. This result suggested that appropriate reimbursement ratios might help to decrease the HR of readmission for patients with diabetes; the latent mechanism for this result will be explored in a future study.

The current study has several limitations. Our baseline variables were disease diagnoses and characteristics of

patients and hospitals. However, there may be more elements contributing to readmissions,^{54 55} such as socioeconomic status of the patients, that were unavailable for the current study. The data of TBMIRS were limited to patients' information contained in claims, and were updated manually. Despite the integrity of these data, some inaccuracies might exist, such as type I and type II diabetes not being distinguished perfectly. Since we lacked data on the transition of care and outpatient care, we could not assess whether our findings were due to inadequacies in these areas.

CONCLUSION

Readmission for patients with diabetes was prevalent in Tianjin, China, and the majority of the patients were readmitted outside of 90 days, followed by within 30 days. Cerebral infarction (type I) and diabetes (type II) were the most frequent conditions for readmission at all time intervals after discharge, and a prior history of diabetes was a risk factor for RFS. Readmission within 7 days after discharge might be more associated with patient characteristics, and readmission at a longer interval might be more affected by the quality of the provided healthcare.

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