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Association between the quality of primary care, insurance coverage, and diabetes-related health outcomes in a cohort of older adults in China: results from the China Health and Retirement Longitudinal Study

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ABSTRACT

Objective This study aims to identify the association between diabetes diagnosis, health outcomes, insurance scheme, and the quality of county-level primary care in a cohort of older Chinese adults.

Design and setting Data from the China Health and Retirement Longitudinal Study, a nationally-representative panel survey of people aged 45 and over in China.

Participants Among participants with valid diabetes-related and hypertension-related medical history and biomarkers (n=8207), participants with diabetes (n=1318) were identified using biomarkers and self-reported medical history. Individual models were run using complete case analysis.

Results Among 1318 individuals with diabetes in 2011, 59.8% were unaware of their disease status. Diagnosis rates were significantly higher among participants with more generous public health insurance coverage (OR 3.58; 95% CI 2.15 to 5.98) and among those with other comorbidities such as dyslipidemia (OR 2.88; 95% CI 2.03 to 4.09). After adjusting for demographics, individuals with more generous public health insurance coverage did not have better glucose control at 4 years follow-up (OR 0.55; 95% CI 0.26 to 1.18) or fewer inpatient hospital admissions at 4 years (OR 1.29; 95% CI 0.72 to 2.33) and 7 years follow-up (OR 1.12; 95% CI 0.62 to 2.05). Individuals living in counties with better county-level primary care did not have better glucose control at 4 years follow-up (OR 0.69; 95% CI 0.01 to 33.36), although they did have fewer inpatient hospital admissions at 4 years follow-up (OR 0.03; 95% CI 0.00 to 0.95). Diabetes diagnosis was a significant independent predictor of both better glucose control at 4 years follow-up (OR 13.33; 95% CI 8.56 to 20.77) and increased inpatient hospital stays at 4 years (OR 1.72; 95% CI 1.20 to 2.47) and 7 years (OR 1.82; 95% CI 1.28 to 2.58) follow-up.

Conclusions These findings suggest that participants with diabetes are often diagnosed concurrently with other comorbid disease conditions or after diabetes-related complications have already developed, thus leading to worse health outcomes in subsequent years despite improvements in health associated with better

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ We used data from the China Health and Retirement Longitudinal Study (CHARLS), a nationally-representative panel survey of people aged 45 and over in China, which contains valuable information on participant demographics, household characteristics, regional characteristics, medical history, and health behaviours, and enables a unique linkage of these variables to patient biomarkers and health outcomes.

⇒ We created a unique county-specific measure of the quality of hypertension-related primary care among the CHARLS cohort, allowing us to assess the relationship between the quality of county-level primary care and diabetes-related health outcomes.

⇒ Our analysis was limited by the lack of biomarkers in 2018, corresponding to the fourth wave of CHARLS, that would have made it possible to assess glucose control for the study cohort at 7 years follow-up.

⇒ Because we were interested in a discrete subsample of participants with diabetes in the CHARLS cohort for our analysis, our results are not generalisable to the broader Chinese population, although they are applicable to a geographically and demographically diverse group of older adults with diabetes in China.

primary care. These findings suggest the importance of strengthening primary care and insurance coverage among older adults to focus on diagnosing and treating diabetes early, in order to prevent avoidable health complications and promote healthy aging.

INTRODUCTION

China's unprecedented economic growth in recent decades has accompanied great strides in population health, including marked decreases in infant mortality and infectious diseases as well as increases in life expectancy.[1] Alongside these demographic and

epidemiological transitions, however, there has been a simultaneous increase in the prevalence and incidence of various non-communicable diseases (NCDs). Mortality and morbidity in China are now most frequently associated with NCDs,[2 3] including a significant and rising disease burden due to diabetes. Studies within the past decade estimate that more than half of China's adult population has diabetes or pre-diabetes,[4 5] representing over 500 million people. This number is projected to rise given China's ageing population and the increasing prevalence of risk factors for diabetes.[6 7] In addition to mortality and morbidity related directly to diabetes, this chronic disease is a risk factor for a wide range of macrovascular and microvascular complications associated with excess mortality in China.[8]

The rising burden of diabetes in China has occurred alongside major health system reforms. A substantive overhaul to the national health insurance and financing system started with pilots in the early 2000s, which established three basic health insurance schemes: New Cooperative Medical Insurance (NCMI) for rural residents, Urban Resident Medical Insurance (URMI) for unemployed or informally employed urban residents and Urban Employee Medical Insurance (UEMI) for formally employed urban residents. As a whole, UEMI is the most generous among the three insurance schemes, as the service benefit packages offered by NCMI and URMI focus on paying for inpatient hospital care with less favorable cost-sharing structures.[9 10] Although these reforms have brought improvements to the Chinese healthcare system,[11 12] major issues remain. These issues include a lack of system-wide integration for the management of chronic diseases and over-utilization of tertiary health facilities due to factors such as the mistrust of primary care providers, who often have fewer years of formal medical training compared with hospital-based practitioners.[13–15]

More than half of people with diabetes in China are unaware of their diagnosis, and even among those who are aware of their diagnosis, the level of control and management of diabetes is often inadequate.[4 5] Suboptimal diagnosis, treatment, and control of diabetes in China, aside from contributing to significant mortality and morbidity, also represent a major economic burden due to lost productivity[16] and inefficient healthcare expenditures.[17 18] Studies in other countries have shown that early diagnosis and management of diabetes yield net value (monetary gains that outweigh the cost of treatment),[19] better patient outcomes, and better quality of life.[20] Better management and integration of patients with chronic diseases within a primary care setting has been associated with improved health outcomes and cost savings,[21] and significant changes in the provision of primary care and outpatient management in China may address existing urban–rural disparities in diabetes-related outcomes and complications.[8 22] Ideally, people with diabetes would receive screening and diagnosis early in the disease process, followed by consistent management in a primary care or outpatient setting. Robust

primary care should lead to better health outcomes, more efficient healthcare utilization, and fewer diabetes-related complications. Previous research has demonstrated that in China, both the initial diagnosis of diabetes[5] and subsequent management and control of diabetes[4] appear to be inadequate, and the underlying factors for these findings are still largely unknown. Our retrospective analysis uses a large panel survey of older adults in China to identify demographic and behavioral factors associated with diabetes diagnosis, and we additionally seek to clarify the relationship between these participants' diabetes diagnosis status, the quality of primary care in their county of residence, and their diabetes-related health outcomes and health utilization in later years.

METHODS
Data source
We used data from the baseline, third, and fourth waves of the China Health and Retirement Longitudinal Study (CHARLS), a nationally-representative panel survey of people aged 45 and over in China,[23] based on a multistage, stratified, random sample drawn at the county, neighbourhood, and household levels. The baseline wave of CHARLS was fielded in 2011–2012, the third wave in 2015, and the fourth wave in 2018. The survey contains information about demographics, income and assets, health status, medical history, health behaviors, and health spending. Biomarkers are collected every other wave beginning with the baseline wave. Therefore, data from the baseline and third waves contain biomarkers relevant to our analysis.

Our analysis used Version D of the Harmonised CHARLS dataset collated by the Gateway to Global Aging Data, which harmonises some variable definitions in the CHARLS dataset with those found in other surveys such as the Health and Retirement Study. Included participants were present in the baseline wave, completed questions about their household geographical region and diabetes medical history, and had fasting plasma glucose measurements and glycosylated hemoglobin (HbA1c) levels; n=9920 (figure 1).

Health status measures
We defined diabetes to align with previous studies of CHARLS conducted by Zhao et al[5] on the prevalence and diagnosis of diabetes. We defined participants with diabetes as those who had one or more of: (1) self-reported diabetes diagnosis; (2) fasting plasma glucose ≥126 mg/dL; or (3) HbA1c concentration ≥6.5% (48 mmol/mol). We defined diabetes diagnosis status as whether participants had a self-reported diabetes diagnosis, regardless of their biomarker levels. We defined diabetes control for participants with a self-reported diabetes diagnosis as HbA1c level ≤7% (53 mmol/mol) or fasting plasma glucose ≤130 mg/dL.[24 25]

We defined participants with hypertension as those who had one or more of: (1) self-reported hypertension
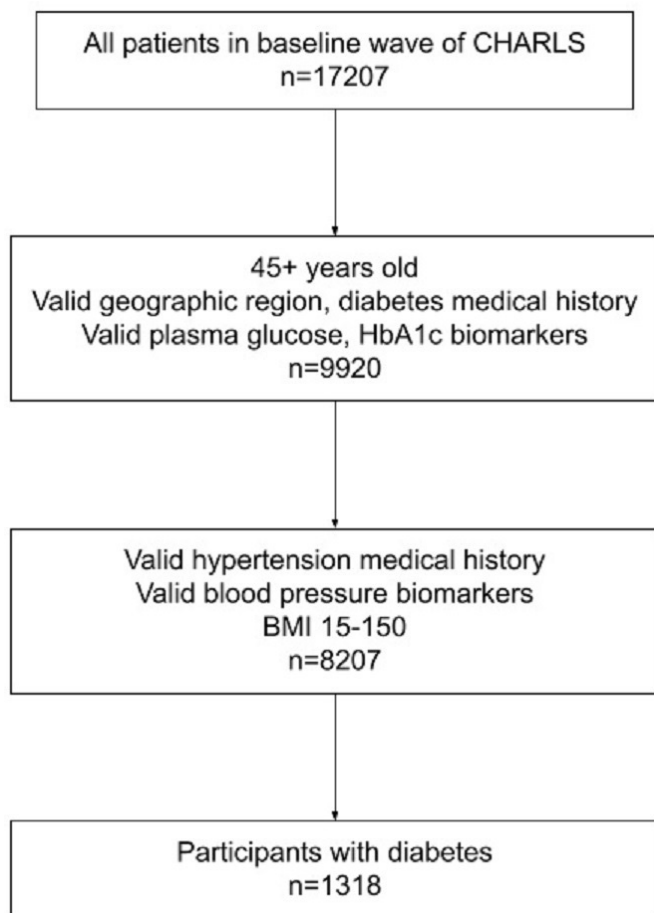
Figure 1 Participant cohort inclusion flow chart. BMI, body mass index; CHARLS, China Health and Retirement Longitudinal Study; HbA1c, glycosylated hemoglobin.

diagnosis; (2) mean systolic blood pressure ≥140 mm Hg; or (3) mean diastolic blood pressure ≥90 mm Hg. We coded systolic blood pressures greater than 230 mm Hg as missing values (n=15). We defined hypertension control for participants with a self-reported hypertension diagnosis as mean blood pressure measurements below 140/90 mm Hg.[26]

Demographic measures

Demographic measures were defined in accordance with prior analyses.[5] We assessed household resources using the log of per capita total household expenditures (PCE) grouped into terciles. We categorised education as illiterate, literate without formal education, formal primary school education, and formal middle school education or above. We used self-reported urban or rural *hukou* (household) status rather than urban or rural residency because *hukou* status establishes eligibility for specific health insurance schemes. We stratified body mass index (BMI) into four intervals, that is, <23, 23–25, 25–30, and ≥30 kg/m^2.[27]

Additionally, we used the community delineator to generate a set of indicator variables describing each participant's province and county of residence, the latter encompassing *qu* (urban district) and *xian* (county). These indicator variables were equal to one if the

participant resided in a given province or county and zero otherwise. We categorised participants' public health insurance status into UEMI, URMI, NCMI and other reported insurance schemes.

Measure of hypertension-related primary care

We used hypertension-related metrics to measure the quality of primary care in each county. Counties actively investing in primary care and management of chronic diseases under China's essential health services program are likely to conduct regular surveillance screening to identify and treat patients with NCDs such as hypertension, resulting in a higher proportion of patients with hypertension under control after adjusting for other observable characteristics of the individuals in that county.

We defined our measure of the quality of hypertension-related primary care in each county as the county average of residuals derived from a linear regression model of hypertension control based on observable individual-level covariates. This measure serves to capture the variation in county-level performance in hypertension control after accounting for individual characteristics. This variable is labelled as 'primary care' in our tables and figures, with a higher average residual representing counties where residents are more likely to have hypertension under control. For detailed methods, please refer to online supplemental appendix A.

Statistical methods

Point estimates of diabetes prevalence in 2011 among the cohort of participants and among demographic subgroups were obtained. These estimates were compared with published findings from Zhao *et al*[5] as a robustness check. We also estimated the percentage of undiagnosed participants with diabetes among the subset of participants (n=1318) with diabetes and among demographic subgroups.

To identify factors associated with diabetes diagnosis status (that is, participants with a self-reported existing diabetes diagnosis) for participants with diabetes in 2011, we fitted a logit model with community and individual-level explanatory variables to assess for covariates that were significantly associated with diabetes diagnosis. To explore factors associated with health outcomes, we conducted binomial logit regressions to examine diabetes control at 4 years follow-up and inpatient hospital stays in the past year at 4 years and 7 years follow-up. All regression models were adjusted for the quality of county-level primary care, which was our main predictor of interest; a vector of individual-level factors including age, sex, education, log PCE, public health insurance scheme, BMI, current smoking status, and self-reported histories of hypertension, heart problems, stroke, dyslipidemia, liver disease, kidney disease; and province-level fixed effects. Finally, to assess for any additional effects of diabetes diagnosis status on health outcomes, we reran those models while including diabetes diagnosis status as our second main predictor of interest. Complete case analysis was

used for all models. All analyses were conducted using Stata SE V.17.[28]

Patient and public involvement

Participants were not involved in the conceptualization, design, or conduct of this study. Participants were not directly recruited for this study. Results from this study will be disseminated via the CHARLS study website alongside other studies that have used data from CHARLS.

RESULTS

Diabetes prevalence and diabetes diagnosis status

Sample descriptive statistics, diabetes prevalence, and the percentage of undiagnosed diabetes among those with diabetes are shown in table 1. In our sample of 8207 participants, 16.1% (n=1318) had diabetes, and among these participants, 59.8% (n=788) of them were undiagnosed. Table 1 also reports these point estimates stratified by primary care quartile, age, sex, education, log PCE, *hukou* status, and public health insurance scheme. We found a very high percentage of participants with diabetes who were undiagnosed among all demographic strata, with more than half undiagnosed participants with diabetes in almost every subgroup except among those with the most generous insurance coverage, UEMI (37.4%), and among those with an urban *hukou* (48.1%). Fortunately, average diagnosis rates are increasing over time for patients with all levels of insurance coverage (online supplemental appendix B).

Factors associated with diabetes diagnosis at baseline

The likelihood of having a diabetes diagnosis was significantly higher among those with UEMI health insurance (OR 3.58; 95% CI 2.15 to 5.98), which is the most generous of China's public health insurance schemes (table 2). Diabetes diagnosis did not differ significantly based on the quality of county-level primary care. Diabetes diagnosis was also significantly associated with having a prior diagnosis of hypertension, heart problems, dyslipidemia, or kidney disease.

Retrospective cohort analyses

Table 3 presents the ORs for diabetes control in 2015. After adjusting for individual characteristics, neither residing in a county with better primary care nor having more generous insurance coverage was significantly associated with diabetes control at 4 years follow-up. However, a prior diagnosis of hypertension, dyslipidemia, or kidney disease was significantly associated with diabetes control in 2015. After including diabetes diagnosis in the regression, hypertension and dyslipidemia were no longer significant independent predictors of diabetes control. Instead, having a diabetes diagnosis at baseline was significantly associated with diabetes control at 4 years follow-up, suggesting that the effect of prior diagnoses of hypertension and dyslipidemia on diabetes control is through the

impact of these comorbidities on the increased likelihood of having a concurrent diabetes diagnosis.

The results of our binomial logit regressions examining inpatient hospital admissions in 2015 and 2018 are presented in table 4. After adjusting for individual

Table 1 Descriptive statistics, diabetes prevalence, and diabetes diagnosis status among the study cohort in the baseline wave of CHARLS

	Participant cohort, % (n=8207)	Diabetes prevalence among participant cohort, % (n=8207)	Undiagnosed diabetes among those with diabetes, % (n=1318)
Total		16.06	59.79
Primary care*			
Lowest quartile	25.34	14.86	67.96
Second quartile	25.53	15.51	62.77
Third quartile	25.22	16.72	52.02
Highest quartile	23.91	17.23	57.4
Insurance			
NCMI	84.32	15.32	63.33
URMI	4.25	20.25	54.55
UEMI	8.31	20.57	37.4
Other	3.12	17.57	61.9
Age			
45–59	50.43	14.23	62.65
60–69	31.59	18.4	54.09
70–79	14.59	17.38	62.98
80+	3.39	15.83	68.18
Sex			
Male	46.75	15.77	64.3
Female	53.25	16.32	55.96
Education			
Illiterate	29.82	15.82	61.24
Literate	18.48	16.74	61.42
Primary	22.21	15.63	56.14
Other	29.49	16.2	59.95
Log PCE†			
First tercile	28.68	15.68	63.69
Second tercile	28.73	15.82	62.47
Third tercile	28.61	17.04	54
Hukou			
Urban	17.33	19.9	48.06
Rural	82.67	15.25	63

*Here, primary care indicates our proxy measure for the quality of primary care in a given patient's county of residence by predicting hypertension control status among individuals residing in that county, controlling for individual-level covariates. Please refer to the text.
†Log of per capita total household expenditures.
CHARLS, China Health and Retirement Longitudinal Study; NCMI, New Cooperative Medical Insurance; UEMI, Urban Employee Medical Insurance; URMI, Urban Resident Medical Insurance.

Table 2 Factors associated with diabetes diagnosis among participants with diabetes in the baseline wave of CHARLS

	Diabetes diagnosis (n=1198)*	
	OR	95% CI
Primary care	5.72	0.40 to 81.96
Insurance		
NCMI		
URMI	1.23	0.66 to 2.26
UEMI	**3.58**	**2.15 to 5.98**
Other	1.06	0.49 to 2.32
Age		
45–59		
60–69	1.18	0.87 to 1.60
70–79	0.91	0.59 to 1.40
80+	0.85	0.38 to 1.86
Female	1.31	0.93 to 1.84
Education		
Illiterate		
Literate	1.12	0.75 to 1.69
Primary	1.30	0.87 to 1.95
Other	0.90	0.59 to 1.36
Log PCE		
First tercile		
Second tercile	1.12	0.79 to 1.60
Third tercile	1.12	0.77 to 1.64
BMI		
<23		
<25	1.17	0.81 to 1.69
<30	1.23	0.88 to 1.73
≥30	1.20	0.68 to 2.12
Current smoker	0.79	0.55 to 1.14
Hypertension	**1.49**	**1.12 to 1.99**
Heart problems	**1.68**	**1.16 to 2.41**
Stroke	0.98	0.51 to 1.88
Dyslipidaemia	**2.88**	**2.03 to 4.09**
Liver disease	1.12	0.58 to 2.14
Kidney disease	**2.49**	**1.46 to 4.25**

Bold values indicate odds ratios with 95% confidence intervals that do not include the null value (OR = 1).

*Here, the sample size is smaller than the total number of participants with diabetes because not all participants had a complete set of covariates for inclusion in the regression.

BMI, body mass index; CHARLS, China Health and Retirement Longitudinal Study; NCMI, New Cooperative Medical Insurance; PCE, per capita total household expenditures; UEMI, Urban Employee Medical Insurance; URMI, Urban Resident Medical Insurance.

characteristics, residing in a county with better primary care was significantly associated with fewer inpatient hospital stays at 4 years follow-up, although this association disappeared by 7 years follow-up. Insurance coverage was not an independent predictor of inpatient hospital stays at 4 years or 7 years follow-up. Diabetes diagnosis was itself an independent predictor of increased inpatient hospital stays at 4 years and 7 years follow-up. As a robustness check, we added diabetes control at baseline as an additional predictor in case of confounding due to participants whose diabetes was under control, which may make them less likely to be hospitalized for a diabetes-related health crisis (online supplemental appendix C). In this supplemental analysis, diabetes diagnosis was an independent predictor of increased inpatient hospital stays at 4 years and 7 years follow-up. Neither residing in a county with better primary care nor having better insurance coverage was significantly associated with inpatient hospital stays at 4 years and 7 years follow-up.

DISCUSSION

Consistent with prior analyses, we found that the majority of participants with diabetes in the CHARLS cohort were undiagnosed at baseline in 2011. We also observed large urban–rural differences: 48.1% of urban residents were undiagnosed compared to 63.0% of rural residents, and 37.4% of UEMI-covered participants were undiagnosed compared to 63.3% of NCMI-covered participants. These rates are consistent with previous studies pointing to large disparities in healthcare outcomes and quality between China's urban and rural populations.[8 29 30]

We found that the quality of hypertension-related primary care within a participant's county of residence was not significantly associated with diabetes diagnosis, suggesting that even locales with relatively good hypertension control did not adequately identify participants with diabetes. Participants who did have a diabetes diagnosis were more likely to be well-insured urban residents under the UEMI scheme and to have comorbid medical conditions. Taken together, these findings suggest that, particularly for rural residents, diabetes diagnosis often occurs in the setting of existing diagnosed comorbidities, likely as an incidental finding during the management of other health conditions, or when diabetes-related complications have already developed.

Hypertension-related primary care was not significantly associated with diabetes control at 4 years follow-up. Better county-level primary care was, however, associated with fewer inpatient hospital stays at 4 years follow-up, though this effect disappeared by 7 years follow-up. There was no significant association between insurance scheme and either diabetes control or inpatient hospital stays, suggesting that insurance coverage impacts diabetes-related health outcomes almost entirely through its effect on diabetes detection and diagnosis. We find that diabetes diagnosis is itself a significant independent predictor of both subsequent diabetes control and inpatient hospital admissions. Together, these findings suggest that diabetes diagnosis is more likely for those with more severe disease

Table 3 Factors associated with diabetes control among participants with diabetes in the third wave (2015) of CHARLS

	Diabetes control* (n=750)†		Adding diagnosis status	
	OR	95% CI	OR	95% CI
Primary care	1.21	0.04 to 35.43	0.69	0.01 to 33.36
Insurance				
NCMI				
URMI	1.37	0.59 to 3.18	1.26	0.47 to 3.37
UEMI	1.11	0.57 to 2.17	0.55	0.26 to 1.18
Other	0.57	0.16 to 2.02	0.61	0.15 to 2.52
Diabetes diagnosis			**13.33**	**8.56 to 20.77**
Age				
45–59				
60–69	0.93	0.63 to 1.37	0.91	0.58 to 1.44
70–79	0.73	0.40 to 1.33	0.91	0.45 to 1.83
80+	1.29	0.38 to 4.38	1.46	0.35 to 6.09
Female	1.29	0.82 to 2.02	1.17	0.70 to 1.95
Education				
Illiterate				
Literate	1.26	0.74 to 2.15	1.20	0.65 to 2.22
Primary	1.15	0.68 to 1.92	0.95	0.53 to 1.73
All else	1.02	0.60 to 1.75	0.89	0.49 to 1.64
Log PCE				
First tercile				
Second tercile	1.28	0.81 to 2.01	1.23	0.72 to 2.09
Third tercile	1.27	0.78 to 2.07	1.21	0.68 to 2.15
BMI				
<23				
<25	1.29	0.79 to 2.11	1.36	0.77 to 2.40
<30	1.08	0.68 to 1.72	1.21	0.71 to 2.07
≥30	0.71	0.33 to 1.52	0.80	0.35 to 1.84
Current smoker	0.81	0.50 to 1.32	0.97	0.55 to 1.69
Hypertension	**1.61**	**1.10 to 2.35**	1.37	0.88 to 2.12
Heart problems	0.92	0.57 to 1.47	0.70	0.41 to 1.19
Stroke	0.87	0.38 to 1.99	0.76	0.30 to 1.95
Dyslipidaemia	**1.81**	**1.17 to 2.78**	1.18	0.73 to 1.93
Liver disease	1.82	0.80 to 4.13	1.75	0.66 to 4.64
Kidney disease	**2.69**	**1.34 to 5.39**	**2.31**	**1.05 to 5.10**

Bold values indicate odds ratios with 95% confidence intervals that do not include the null value (OR = 1).
*Diabetes control is defined for participants with a self-reported diabetes diagnosis as HbA1c ≤7% (53 mmol/mol) or fasting plasma glucose ≤130 mg/dL.
†Here, the sample size is smaller than the total number of participants with diabetes because not all participants had a complete set of covariates for inclusion in the regression.
BMI, body mass index; CHARLS, China Health and Retirement Longitudinal Study; HbA1c, glycosylated haemoglobin; NCMI, New Cooperative Medical Insurance; PCE, per capita total household expenditures; UEMI, Urban Employee Medical Insurance; URMI, Urban Resident Medical Insurance.

or comorbid medical conditions, such that even for patients with adequate glucose control, participants with a diabetes diagnosis remain at risk of becoming seriously ill and requiring an inpatient hospital stay.

Given that better county-level primary care is associated with fewer inpatient hospital stays despite no association with glucose control, we propose that though improvements in hypertension-related primary care

Table 4 Factors associated with inpatient hospital stays among participants with diabetes in the third wave (2015) and fourth wave (2018) of CHARLS

	Hospital stay in 2015 (n=1023)*		Adding diagnosis status		Hospital stay in 2018 (n=941)*		Adding diagnosis status	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Primary care	0.04	0.00 to 1.14	**0.03**	**0.00 to 0.95**	7.31	0.28 to 192.55	7.10	0.26 to 190.24
Insurance								
NCMI								
URMI	1.48	0.71 to 3.07	1.48	0.71 to 3.08	1.66	0.79 to 3.47	1.56	0.74 to 3.29
UEMI	1.50	0.84 to 2.67	1.29	0.72 to 2.33	1.31	0.73 to 2.36	1.12	0.62 to 2.05
Other	1.21	0.46 to 3.13	1.18	0.45 to 3.08	1.19	0.47 to 3.02	1.17	0.45 to 3.01
Diabetes diagnosis			**1.72**	**1.20 to 2.47**			**1.82**	**1.28 to 2.58**
Age								
45–59								
60–69	1.05	0.71 to 1.55	1.06	0.72 to 1.56	1.37	0.95 to 1.97	1.38	0.95 to 1.99
70–79	**1.82**	**1.10 to 3.01**	**1.89**	**1.14 to 3.14**	1.27	0.75 to 2.17	1.34	0.78 to 2.30
80+	1.53	0.57 to 4.09	1.56	0.58 to 4.19	1.68	0.53 to 5.35	1.77	0.55 to 5.67
Female	0.85	0.56 to 1.29	0.84	0.55 to 1.28	0.87	0.58 to 1.31	0.85	0.56 to 1.28
Education								
Illiterate								
Literate	1.57	0.97 to 2.54	1.57	0.97 to 2.56	1.03	0.64 to 1.67	1.03	0.63 to 1.68
Primary	0.88	0.52 to 1.47	0.85	0.50 to 1.42	0.94	0.57 to 1.53	0.89	0.54 to 1.47
All else	1.05	0.62 to 1.77	1.05	0.62 to 1.78	0.94	0.57 to 1.54	0.93	0.57 to 1.53
Log PCE								
First tercile								
Second tercile	1.16	0.75 to 1.79	1.11	0.71 to 1.72	0.81	0.54 to 1.23	0.79	0.52 to 1.20
Third tercile	1.01	0.64 to 1.61	0.97	0.61 to 1.55	0.80	0.52 to 1.25	0.79	0.51 to 1.24
BMI								
<23								
<25	1.29	0.82 to 2.03	1.30	0.82 to 2.05	1.11	0.71 to 1.75	1.12	0.71 to 1.77
<30	0.95	0.61 to 1.47	0.95	0.61 to 1.48	1.07	0.70 to 1.63	1.07	0.70 to 1.64
≥30	1.06	0.54 to 2.10	1.08	0.54 to 2.13	0.99	0.50 to 1.95	1.03	0.52 to 2.03
Current smoker	0.71	0.45 to 1.11	0.74	0.47 to 1.17	0.79	0.51 to 1.22	0.82	0.53 to 1.27
Hypertension	**1.68**	**1.17 to 2.43**	**1.59**	**1.10 to 2.30**	1.37	0.96 to 1.95	1.29	0.90 to 1.85
Heart problems	**1.57**	**1.02 to 2.40**	1.47	0.95 to 2.26	**1.62**	**1.06 to 2.49**	1.52	0.99 to 2.33
Stroke	1.12	0.52 to 2.42	1.09	0.50 to 2.36	1.14	0.52 to 2.47	1.14	0.52 to 2.49
Dyslipidaemia	1.13	0.74 to 1.74	1.00	0.65 to 1.55	1.31	0.87 to 2.00	1.13	0.74 to 1.74
Liver disease	1.28	0.58 to 2.83	1.29	0.58 to 2.86	0.98	0.45 to 2.14	0.96	0.44 to 2.11
Kidney disease	1.51	0.83 to 2.76	1.39	0.76 to 2.55	1.23	0.64 to 2.37	1.15	0.60 to 2.22

Bold values indicate odds ratios with 95% confidence intervals that do not include the null value (OR = 1).
*Here, the sample size is smaller than the total number of participants with diabetes because not all participants had a complete set of covariates for inclusion in the regression.
BMI, body mass index; CHARLS, China Health and Retirement Longitudinal Study; NCMI, New Cooperative Medical Insurance; PCE, per capita total household expenditures; UEMI, Urban Employee Medical Insurance; URMI, Urban Resident Medical Insurance.

may keep individuals out of the hospital for comorbid conditions, it is still not adequately addressing diabetes control and management.

Finally, we were interested in a brief back-of-the-envelope comparison of healthcare spending among participants across primary care quartiles and insurance

scheme, presented in online supplemental appendix D. We summarize reported out-of-pocket spending as a portion of household income as proxied by PCE in 2011. Those in the highest primary care quartile and those with NCMI health insurance reported higher out-of-pocket spending as a fraction of household income. These differences ceased to be significant in 2015 and 2018, raising the question of whether health outcomes in later waves of CHARLS are related to higher baseline healthcare utilization and spending or whether improved benefits for NCMI may have reduced financial barriers to care. The spending data available in CHARLS is based on self-recall; thus, total medical spending is likely underestimated since many participants are unaware or not informed of the total amount billed when they seek medical care. In future studies, examining the role of healthcare spending and healthcare utilization vis-a-vis public insurance coverage will help to provide further insight into whether and how earlier diagnosis, management, and control of diabetes in China yield net value for both patients and health systems.

A chronic disease diagnosis, such as for diabetes, should be followed by appropriate treatment and management to prevent avoidable hospitalizations and disease-related complications. The low diagnosis rate among participants with diabetes in the CHARLS cohort, and, counterintuitively, worse health outcomes (proxied by an inpatient hospital stay) among those diagnosed, suggest inadequate primary care or outpatient management of diabetes in China. These findings suggest that primary care provides relatively poor identification of at-risk patients and does not adequately address the insidious onset of diabetes; thus, individuals are often diagnosed with diabetes only when they experience severe symptoms or complications related to diabetes, or as incidental diagnoses in the setting of other comorbid medical conditions such as hypertension. Diagnosis later in the disease course of diabetes or in conjunction with other comorbid medical conditions is associated with more intractable disease and worse prognosis,[20 31] which could explain the increased hospitalizations for participants with a diabetes diagnosis in 2011.

Our analysis was limited by the lack of biomarkers in 2018, corresponding to the fourth wave of CHARLS, that would have made it possible to assess glucose control for the study cohort at 7 years follow-up. It is possible that with the ongoing implementation of health reforms in China designed to better integrate primary care and tertiary hospital systems, some of the areas of improvement that we noted are already being addressed. Additionally, because we were interested in a discrete subsample of the CHARLS cohort for our analysis, our results are not generalizable to the broader Chinese population, although they can be interpreted as applicable to a geographically and demographically diverse group of older adults with diabetes in China.

CONCLUSIONS

Diabetes-related primary care is particularly important because poor screening and management of diabetes often leads to severe complications, with associated high morbidity and mortality.[7 32 33] Our analyses of CHARLS data through 2018 highlight the importance of strengthening NCD management and control in China's primary care system and health insurance schemes. Although diagnosis rates are improving on average for all insurance schemes, CHARLS participants are most likely to be aware of their condition if they are covered by more generous health insurance (UEMI) or if they have other comorbid chronic conditions. Participants with a diabetes diagnosis are more likely to experience an inpatient hospitalization compared to observably similar participants who are as yet undiagnosed for their underlying diabetes condition, whether or not they reside in a county with relatively good hypertension-related primary care. These findings suggest that a diabetes diagnosis is proxying for more severe disease and that participants with diabetes are likely receiving diagnoses in the setting of other comorbid conditions or diabetes-related complications, thus explaining why they may be more likely to have better glucose control (because they are receiving treatment) yet also more likely to experience an inpatient hospitalization. Given the aging population and the explosive increase of diabetes-related risk factors in China, the early diagnosis and treatment of diabetes among older adults is essential to improve patient health outcomes and prevent avoidable complications.

consent, and one copy was kept in the CHARLS office, which was also scanned and saved in PDF format. Four separate consents were obtained: one for the main fieldwork, one for the non-blood biomarkers and one for the taking of the blood samples, and another for storage of blood for future analyses.

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Data availability statement Data are available on reasonable request. All data relevant to the study are included in the article or uploaded as online supplemental information. Access to the data used for this study may be obtained from the CHARLS study website maintained by Peking University at http://charls.pku.edu.cn/index/en.html.

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