Preplanned Studies

The Cascade of Care for Diabetes and Risks of Functional Limitation — China, 2011–2020

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Summary

What is already known about this topic?

Uncontrolled diabetes can result in severe clinical complications, significantly increasing the risk of functional limitations in instrumental activities of daily living (IADL) and activities of daily living (ADL).

What is added by this report?

This study investigates the association between the Cascade of Care (CoC) for diabetes and functional limitations, providing evidence on the critical need for strengthening diabetes care to prevent functional limitations and improve quality of life.

What are the implications for public health practice?

The findings provide critical insights to guide public health strategies and interventions aimed at enhancing diabetes management across all stages of the CoC, with the goal of reducing functional limitations and their associated burden, ultimately improving long-term health outcomes for individuals with diabetes.

ABSTRACT

Introduction: Diabetes, if not treated well, can result in severe clinical complications and physical limitation. This study investigates gaps in the Cascade of Care (CoC) for diabetes among individuals aged 45 and older in China and its association with the risk of functional limitations.

Methods: Using data from the China Health and Retirement Longitudinal Study (CHARLS) from 2011 to 2020, the study analyzes the association between CoC and limitations in activities of daily living (ADL) and instrumental activities of daily living (IADL) through generalized estimating equations and Cox proportional hazards models. The CoC for diabetes consisted of five stages.

Results: The largest gap was found in the awareness stage (59.6%), while smaller gaps were observed in the transition from awareness to treatment (13.8%) and treatment-to-control (9.0%). Compared to individuals without diabetes, those in stages 1, 2, and 3 of the CoC had a significantly higher risk of ADL/IADL limitation, with stage 3 having the most pronounced impact.

Conclusions: The findings highlight poor diabetes management in China, especially in awareness and treatment stages, and show that low awareness, treatment, and glycemic control are linked to higher future risk of functional limitations. Early diagnosis and effective diabetes management are crucial to reducing these risks.

Recent studies estimate that approximately 12.4% of Chinese adults have diabetes (*1*), exceeding the global average of 1 in 9 (*2*), which poses a significant public health burden. Poorly managed diabetes can lead to severe complications and physical limitations. The Cascade of Care (CoC) model outlines the stages of long-term care (prevalence, screening, diagnosis, treatment, follow-up, and control), providing a framework for improving disease outcomes by identifying care gaps (*3*). Addressing these gaps is critical for improving health outcomes. However, the association between CoC for diabetes and associated health losses, such as functional limitations, remains underexplored. Gaining insights into this association could be key to enhancing diabetes management and reducing the risk of functional limitation.

This study used data from the China Health and Retirement Longitudinal Study (CHARLS), a nationally representative cohort of Chinese adults aged 45 and older. The survey, initiated in 2011, employed a multistage stratified probability proportional to size (PPS) sampling method, covering 17,708 participants from 10,257 households across 28 provincial-level administrative divisions (PLADs). Follow-up interviews were conducted in 2013, 2015, 2018, and

2020 (4). After excluding cases with missing data at baseline, 10,945 individuals were included in the analysis. A care cascade framework for diabetes was used to evaluate management conditions, including diagnosis/awareness (self-reported diagnosis or high fasting blood glucose), treatment (receiving any treatment), and control (blood glucose or HbA1c within target levels). The CoC was divided into five stages: without diabetes (Stage 0), unaware (Stage 1), aware but untreated (Stage 2), treated but uncontrolled (Stage 3), and awareness-treated-controlled (stage 4). Functional limitations were defined as difficulty in any activities of IADL and activities of ADL and assessed using two variables: number of limitations (0 to 6) with a Generalized Estimating Equation (GEE) model and presence of any limitation using the Cox proportional hazards model.

The GEE model and Cox proportional hazards model were used to assess the association between CoC and ADL/IADL limitations, as well as specific functional domains. The GEE model utilized observations with repeated measurements from 2011 to 2020, applying Poisson distribution for the multi-categorical ADL/IADL limitations and logistic distribution for the dichotomous ADL/IADL items. In the Cox model, participants with baseline ADL/IADL limitations were excluded to examine the risk of new functional limitations. All models adjusted for age, gender, marital status, educational attainment, working status, total household consumption, smoking status, drinking status, Body Mass Index (BMI) and hypertension (HBP). Statistical analysis was conducted using STATA 17.0 (StataCorp LLC, College Station, TX, USA), with a significance level set at $P<0.05$.

In 2011, 15.8% of individuals were identified as having diabetes. Among these individuals, 40.4% were aware of their condition, 26.6% received treatment, and only 17.6% successfully achieved glycemic control. The largest gap in the CoC occurred at the awareness stage, with 59.6% of diabetics unaware of their condition, followed by a 13.8% drop between awareness and treatment, and a smaller gap (9.0%) between treatment and control. These findings highlight critical shortcomings in diabetes care management in China. In 2011, 17.2% of respondents experienced limitations in ADL and 21.6% experienced limitations in IADL, with the prevalence of these limitations increasing over time. Table 1 andSupplemental Table S1 (available at https://weekly.chinacdc.cn/) illustrate the prevalence of ADL and IADL limitations over time and across different stages of the CoC. The prevalence of these limitations increased over time at all stages, with higher rates observed among those with poorer diabetes management. Notably, the prevalence significantly decreased as diabetes was better managed along the care cascade.

The GEE model examined the association between CoC and ADL/IADL limitations across 47,920 observations from 2011 to 2020 (Table 2 and

TABLE 1. Prevalence of ADL/IADL limitations over time at different stages of the diabetes care cascade.

Subgroup	Total	Year					*P*
		2011	2013	2015	2018	2020	
ADL limitation							
CoC Stage 0	21.1	16.4	18.3	22.9	22.7	26.8	<0.001
CoC Stage 1	24.8	20.7	22.0	26.3	26.8	30.1	<0.001
CoC Stage 2	26.8	17.4	22.5	30.8	29.6	37.0	<0.001
CoC Stage 3	32.8	27.6	29.4	35.2	32.9	42.5	0.001
CoC Stage 4	29.4	24.8	27.9	29.4	31.2	36.0	0.072
IADL limitation							
CoC Stage 0	26.3	20.8	25.3	28.0	29.1	29.7	<0.001
CoC Stage 1	28.8	23.1	27.6	30.2	32.6	32.1	<0.001
CoC Stage 2	30.8	23.3	26.9	32.5	39.9	34.0	<0.001
CoC Stage 3	34.1	32.0	24.9	34.0	38.9	45.2	<0.001
CoC Stage 4	30.9	33.3	23.4	30.3	30.1	38.2	0.320

Note: CoC Stage 0=without diabetes; CoC Stage 1=unaware; CoC Stage 2=aware but untreated; CoC Stage 3=treated but uncontrolled; CoC Stage 4=awareness-treated-controlled.
Abbreviation: ADL=activities of daily living; IADL=instrumental activities of daily living.

Supplemental Table S2, available at https://weekly.chinacdc.cn/). Stage 3 (treated but uncontrolled) was significantly associated with a 59.6% increased risk of ADL limitations compared to those without diabetes, affecting all ADL items (59.5%–119.3%). Stage 1 (unaware) raised risks for bathing (19.6%) and eating (35.6%), while stage 4 (awareness-treated-controlled) increased risks for bathing (60.4%) and controlling urination/defecation (125.0%). For IADL, stage 3 was associated with a 42.5% increased risk overall and elevated risks for housework (96.9%), meal preparation (99.1%), shopping (61.1%), and money management (43.9%). Stage 1 was linked to a 17.9% higher risk in shopping, while stages 2 and 4 showed no significant associations.

The Cox proportional hazards model analyzed the impact of CoC on new-onset functional limitations in 7,873 individuals without baseline ADL/IADL limitations (Table 3 and Supplemental Table S3, available at https://weekly.chinacdc.cn/). For ADL limitations, compared to those without diabetes, the risk increased by 32.3% in Stage 2 and 67.9% in Stage 3, with no significant associations observed in stages 1 and 4. Stage 1 was associated with increased risks ranging from 34.1% to 52.2% for specific activities including dressing, bathing, eating, and getting in/out of bed, while Stage 3 showed elevated risks of 47.8% to 109.7% across all ADL domains except eating. For

TABLE 2. Association between cascade of diabetes care and limitation in ADL/IADL using generalized estimating equation model.

Subgroup	IRR (95% *CI*)
ADL	
With diabetes but unaware	1.094 (0.985, 1.215)
Being awareness but not treated	1.127 (0.933, 1.362)
Treated but uncontrolled	1.596 (1.361, 1.871)*
Awareness, treated and controlled	1.314 (0.993, 1.741)
IADL	
With diabetes but unaware	1.060 (0.966, 1.163)
Being awareness but not treated	1.079 (0.908, 1.282)
Treated but uncontrolled	1.425 (1.226, 1.656)*
Awareness, treated and controlled	1.143 (0.872, 1.499)

Note: All models were adjusted for age, gender, marital status, educational attainment, working status, total household consumption, smoking status, drinking status, body mass index, and hypertension.
Abbreviation: ADL=activities of daily living; IADL=instrumental activities of daily living; IRR=incidence rate ratio; *CI*=confidence interval.
* $P<0.05$.

TABLE 3. Association between cascade of diabetes care and new limitation in ADL/IADL using Cox proportional hazards model.

Subgroup	*HR* (95% *CI*)
ADL	
With diabetes but unaware	1.131 (0.976, 1.312)
Being awareness but not treated	1.323 (1.032, 1.694)*
Treated but uncontrolled	1.679 (1.302, 2.164)*
Awareness, treated and controlled	1.302 (0.853, 1.987)
IADL	
With diabetes but unaware	1.120 (0.980, 1.280)
Being awareness but not treated	1.050 (0.815, 1.353)
Treated but uncontrolled	1.307 (1.014, 1.685)*
Awareness, treated and controlled	1.045 (0.685, 1.594)

Note: All models were adjusted for age, gender, marital status, educational attainment, working status, total household consumption, smoking status, drinking status, Body Mass Index and hypertension.
Abbreviation: ADL=activities of daily living; IADL=instrumental activities of daily living; *HR*=hazard ratio; *CI*=confidence interval.
* $P<0.05$.

IADL limitations, Stage 3 was the only stage significantly associated with an increased risk, showing a 1.307-fold increase. Stage 1 increased the risk for meal preparation and shopping by 26.5% and 33.3%, respectively, and Stage 2 elevated the risk in medication management by 58.0%. No significant associations were found for managing money across any stage. All models were tested for proportional-hazards assumption (P>0.05, Supplemental Table S4, available at https://weekly.chinacdc.cn/).

DISCUSSION

This study revealed significant gaps in diabetes care cascade performance across China, reflecting poor nationwide diabetes control. Individuals at stages 1, 2, and 3 of the CoC, representing progressively poorer diabetes management, demonstrated higher rates of ADL and IADL limitations, with Stage 3 showing the strongest associations. Additionally, new-onset functional impairments were more likely to develop in stages 2 and 3, underscoring the critical need for improved diabetes care.

Our results reemphasized the substantial gaps in diabetes management among Chinese adults aged 45 and older. Of the 15.8% with diabetes, only 40.4% were aware of their condition, 26.6% received treatment, and merely 17.6% achieved glycemic control. Similarly, another national study reported comparably low rates of awareness (41.0%), treatment (32.7%), and control (6.2%) (*5*). These rates were notably lower than those in countries like the Republic of Korea, where the corresponding figures were 69.2%, 63.5%, and 28.0% in 2016–2017 (*6*). While differences in diabetes definitions, study populations, and data collection methods may partially explain these disparities, strengthening awareness, treatment, and control remains critical to preventing complications and improving health outcomes in China.

Our findings provide new insights into the association between CoC and ADL/IADL limitations. Notably, treated but uncontrolled diabetes (Stage 3) increased the probability of limitations across most functional domains. Poor glycemic management raises the likelihood of complications such as cardiovascular disease (*7*) and muscle strength decline (*8*), which can significantly restrict physical function. Being unaware of diabetes (stage 1) was also associated with a higher risk of limitations in most items, despite not being directly linked to overall ADL/IADL limitations. This may be attributed to prolonged disease duration before diagnosis, as longer diabetes duration has been linked to poor glycemic control (*9*). Previous studies have suggested that functional limitations increase with the duration of diabetes (*10*). Although our study could not directly examine the specific impact of diabetes duration on limitation risk, the results support these conclusions indirectly.

To our knowledge, this is the first nationally representative study to comprehensively examine the association between the CoC and risk of functional limitations in China. Our study has several strengths. First, it utilizes data from a longitudinal, nationally representative survey, ensuring generalizability to Chinese adults aged 45 and older. Second, the prospective Cox proportional hazards model enables evaluation of the temporal association between CoC and the incidence of functional limitations. Third, the study employs a robust definition of diabetes that includes self-reported cases, HbA1c values, and diabetes medication use.

These findings highlight the crucial link between effective diabetes management and the prevention of functional limitations, emphasizing the need for improved CoC within the healthcare system. Our results can guide policymakers in prioritizing improvements to the diabetes care pathway, reducing the burden of limitations among older adults and promoting healthy aging. Identifying CoC gaps and their association with functional limitations can help design targeted educational programs for healthcare providers and patients, thereby improving health outcomes and quality of life for individuals with diabetes.

Interpreting these data involves several limitations. First, as nutrition is a major risk factor for diabetes, the lack of dietary assessments may restrict our understanding of CoC and limitation risk. However, we adjusted for other socioeconomic and behavioral factors, which helps mitigate some of this bias. Second, this study did not account for the co-existence of other conditions, which may overestimate the CoC level and underestimate the association between CoC loss and functional limitations because multimorbidity is more likely to contribute to adverse health outcomes. Nevertheless, the incidence of other conditions like stroke in this study is relatively low (5%), potentially reducing their impact on the results. Third, the study population consists of middle-aged and elderly individuals, which may limit the generalizability of our findings to the broader population, and caution is needed when extrapolating these results. Further

research is needed to fully understand the relationship between CoC and limitation risk, particularly regarding diabetes duration.

In conclusion, this study revealed inadequate diabetes management along the CoC for Chinese adults aged 45 and older, indicating a significant unmet demand for diabetes care and challenges in achieving universal health coverage. Low awareness, treatment, and control significantly increase the risk of functional limitations, especially when diabetes is unrecognized or poorly managed. This emphasizes the urgent need to enhance the CoC to mitigate functional decline in the aging population. Raising early awareness and ensuring timely treatment are crucial for reducing limitations among individuals with diabetes. The findings also provide valuable insights for policymakers and service providers to identify diabetes care priorities.

Conflicts of interest: No conflict of interest.

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SUPPLEMENTARY MATERIAL

SUPPLEMENTARY TABLE S1. Prevalence of ADL and IADL limitations over time.

Subgroup	Total	Year					*P*
		2011	2013	2015	2018	2020	
ADL limitation	22.0	17.2	19.1	23.8	23.5	27.7	<0.001
IADL limitation	26.9	21.6	25.6	28.5	29.9	30.4	<0.001

Abbreviation: ADL=activities of daily living; IADL=instrumental activities of daily living.

SUPPLEMENTARY TABLE S2. Association between cascade of diabetes care and limitation in the domains of ADL/IADL using generalized estimating equation model.

Subgroup	*OR* (95% *CI*)	Subgroup	*OR* (95% *CI*)
Dressing		Doing housework	
With diabetes but unaware	1.110 (0.922, 1.337)	With diabetes but unaware	1.049 (0.908, 1.213)
Being awareness but not treated	1.271 (0.908, 1.761)	Being awareness but not treated	1.093 (0.841, 1.421)
Treated but uncontrolled	1.742 (1.307, 2.321)*	Treated but uncontrolled	1.969 (1.583, 2.450)*
Awareness, treated and controlled	1.383 (0.840, 2.279)	Awareness, treated and controlled	1.207 (0.809, 1.801)
Bathing		Preparing hot meals	
With diabetes but unaware	1.196 (1.008, 1.420)*	With diabetes but unaware	1.098 (0.937, 1.288)
Being awareness but not treated	1.130 (0.821, 1.554)	Being awareness but not treated	1.101 (0.822, 1.475)
Treated but uncontrolled	2.193 (1.704, 2.822)*	Treated but uncontrolled	1.991 (1.569, 2.526)*
Awareness, treated and controlled	1.604 (1.030, 2.498)*	Awareness, treated and controlled	1.227 (0.791, 1.904)
Eating		Shopping	
With diabetes but unaware	1.356 (1.070, 1.720)*	With diabetes but unaware	1.179 (1.008, 1.381)*
Being awareness but not treated	0.921 (0.544, 1.557)	Being awareness but not treated	0.986 (0.725, 1.341)
Treated but uncontrolled	1.753 (1.181, 2.603)*	Treated but uncontrolled	1.611 (1.246, 2.083)*
Awareness, treated and controlled	1.237 (0.587, 2.604)	Awareness, treated and controlled	1.026 (0.635, 1.657)
Getting in/out of bed		Taking medications	
With diabetes but unaware	1.071 (0.896, 1.280)	With diabetes but unaware	1.057 (0.880, 1.271)
Being awareness but not treated	1.126 (0.817, 1.551)	Being awareness but not treated	1.222 (0.887, 1.683)
Treated but uncontrolled	1.610 (1.217, 2.130)*	Treated but uncontrolled	1.249 (0.913, 1.710)
Awareness, treated and controlled	1.432 (0.898, 2.285)	Awareness, treated and controlled	1.249 (0.751, 2.072)
Using the toilet		Managing money	
With diabetes but unaware	1.079 (0.936, 1.243)	With diabetes but unaware	1.098 (0.953, 1.266)
Being awareness but not treated	1.049 (0.809, 1.360)	Being awareness but not treated	1.108 (0.854, 1.439)
Treated but uncontrolled	1.595 (1.271, 2.003)*	Treated but uncontrolled	1.439 (1.135, 1.824)*
Awareness, treated and controlled	1.399 (0.956, 2.047)	Awareness, treated and controlled	0.885 (0.562, 1.394)
Controlling urination and defecation			
With diabetes but unaware	1.105 (0.902, 1.352)		
Being awareness but not treated	1.388 (0.983, 1.961)		
Treated but uncontrolled	1.961 (1.451, 2.650)*		
Awareness, treated and controlled	2.250 (1.418, 3.571)*		

Note: All models were adjusted for age, gender, marital status, educational attainment, working status, total household consumption, smoking status, drinking status, Body Mass Index and hypertension.
Abbreviation: ADL=activities of daily living; IADL=instrumental activities of daily living; *OR*=odds ratio; *CI*=confidence interval.
* *P*<0.05.

SUPPLEMENTARY TABLE S3. Association between cascade of diabetes care and new limitation in the domains of ADL/IADL using Cox proportional hazards model.

Subgroup	*HR* (95% *CI*)	Subgroup	*HR* (95% *CI*)
Dressing		Doing housework	
With diabetes but unaware	1.341 (1.060, 1.697)*	With diabetes but unaware	1.108 (0.927, 1.326)
Being awareness but not treated	1.600 (1.080, 2.369)*	Being awareness but not treated	1.291 (0.954, 1.747)
Treated but uncontrolled	1.906 (1.267, 2.868)*	Treated but uncontrolled	1.812 (1.356, 2.417)*
Awareness, treated and controlled	0.730 (0.272, 1.958)	Awareness, treated and controlled	0.853 (0.457, 1.594)
Bathing		Preparing hot meals	
With diabetes but unaware	1.363 (1.090, 1.704)*	With diabetes but unaware	1.265 (1.037, 1.542)*
Being awareness but not treated	1.404 (0.961, 2.051)	Being awareness but not treated	1.235 (0.863, 1.766)
Treated but uncontrolled	2.097 (1.452, 3.028)*	Treated but uncontrolled	2.050 (1.489, 2.822)*
Awareness, treated and controlled	1.147 (0.543, 2.425)	Awareness, treated and controlled	1.040 (0.537, 2.012)
Eating		Shopping	
With diabetes but unaware	1.522 (1.082, 2.139)*	With diabetes but unaware	1.333 (1.085, 1.638)*
Being awareness but not treated	1.635 (0.905, 2.952)	Being awareness but not treated	1.358 (0.937, 1.966)
Treated but uncontrolled	1.731 (0.880, 3.404)	Treated but uncontrolled	1.912 (1.332, 2.743)*
Awareness, treated and controlled	0.943 (0.233, 3.815)	Awareness, treated and controlled	1.158 (0.575, 2.331)
Getting in/out of bed		Taking medications	
With diabetes but unaware	1.263 (1.007, 1.584)*	With diabetes but unaware	1.173 (0.907, 1.517)
Being awareness but not treated	1.634 (1.144, 2.334)*	Being awareness but not treated	1.580 (1.058, 2.360)*
Treated but uncontrolled	1.603 (1.059, 2.425)*	Treated but uncontrolled	1.373 (0.841, 2.240)
Awareness, treated and controlled	1.414 (0.730, 2.739)	Awareness, treated and controlled	1.806 (0.930, 3.506)
Using the toilet		Managing money	
With diabetes but unaware	1.133 (0.949, 1.352)	With diabetes but unaware	1.092 (0.901, 1.324)
Being awareness but not treated	1.233 (0.914, 1.662)	Being awareness but not treated	1.302 (0.938, 1.806)
Treated but uncontrolled	1.478 (1.081, 2.022)*	Treated but uncontrolled	1.367 (0.957, 1.952)
Awareness, treated and controlled	1.516 (0.948, 2.423)	Awareness, treated and controlled	0.797 (0.396, 1.601)
Controlling urination and defecation			
With diabetes but unaware	1.271 (0.971, 1.663)		
Being awareness but not treated	1.336 (0.846, 2.108)		
Treated but uncontrolled	1.967 (1.271, 3.046)*		
Awareness, treated and controlled	1.177 (0.485, 2.856)		

Note: All models adjusted for age, gender, marital status, educational attainment, working status, total household consumption, smoking status, drinking status, Body Mass Index and hypertension.
Abbreviation: ADL=activities of daily living; IADL=instrumental activities of daily living; *HR*=hazard ratio; *CI*=confidence interval.
* $P<0.05$.

SUPPLEMENTARY TABLE S4. Results of test for proportional-hazards assumption.

Subgroup	*P*	Subgroup	*P*
ADL	0.61	IADL	0.18
Dressing	0.28	Doing housework	0.07
Bathing	0.06	Preparing hot meals	0.10
Eating	0.13	Shopping	0.64
Getting in/out of bed	0.43	Taking medications	0.72
Using the toilet	0.66	Managing money	0.37
Controlling urination and defecation	0.47		

Abbreviation: ADL=activities of daily living; IADL=instrumental activities of daily living.