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Changes in pre-diabetes and diabetes prevalence and diabetes self-management behaviors across socioeconomic spectra in rural southwest China: 2013–2022

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Abstract

Background This study aimed to uncover the changing prevalence of pre-diabetes and diabetes as well as diabetes self-management behaviors across socioeconomic gradients in rural southwest China.

Methods A two-wave, community-based, cross-sectional survey was conducted. A total of 7,747 and 7,536 individuals aged ≥ 35 years, residing in rural southwest China, were selected using a three-stage stratified random sampling method. Demographic characteristics and self-management behaviors were collected through face-to-face interviews, and physical indicators were measured through on-site examinations. An individual socioeconomic position (SEP) index was constructed using principal component analysis based on three variables: education, annual household income, and access to medical services.

Results In 2022, the overall prevalence of pre-diabetes and diabetes (15.7% and 7.6%) were lower than in 2013 (18.3% and 8.2%) ($P < 0.05$). This decline was also observed in subgroups including women, those aged 45–54 years, those of Han ethnicity, those with a high educational level, those with a high annual household income, and those with good access to medical services and high SEP ($P < 0.05$). In contrast, higher rates were found among ethnic minorities, those with low annual household income, and those with low SEP. The overall rate of compliance with anti-diabetic medications or insulin injection was higher in 2022 (95.9%) compared to 2013 (76.5%), with the largest relative increase occurring among participants with a low level of education and income, poor access to medical services, and low SEP ($P < 0.01$). The proportion of individuals having taken measures to control diabetes was lower in 2022 (39.7%) compared to 2013 (53.3%) ($P < 0.01$). This lower rate was also observed among the subgroups categorized by sex, education, and income level, in the Han majority, and among participants with good access to medical services and high SEP ($P < 0.05$). Furthermore, while the overall rate of regular self-monitoring of blood glucose did not differ between the two survey years (41.8% and 44.7%, $P > 0.05$), a higher rate was uncovered among patients with low education level, low annual household income, poor access to medical services, and low SEP in 2022 compared to 2013 ($P < 0.05$).

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Conclusions The prevalence of pre-diabetes and diabetes, as well as the rate of taking measures to control diabetes, were lower among the rural Chinese adult population in 2022 compared with 2013. However, compliance with anti-diabetes medications or insulin injections was higher. Additionally, socioeconomic disparities are associated with these Changes.

Keywords China, Change, Diabetes, Diabetes self-management behaviors, Pre-diabetes, Rural residents

Introduction

There has been a gradual increase in the incidence of pre-diabetes, a condition that is between normal blood glucose levels and diabetes and is a risk factor for type 2 diabetes [1], and its rise is now also a critical public health issue and a major threat to the future development of diabetes and its complications [2].

As the seventh largest cause of death worldwide, and with its prevalence rapidly increasing on a global scale, particularly in countries with low to middle incomes, diabetes is one of the most prevalent chronic diseases globally [3, 4]. Specifically, diabetes causes fatal, disabling, and financially costly complications as well as premature death and reduced life expectancy [5, 6]. According to the International Diabetes Federation (IDF) [5, 7], the global Disability-Adjusted Life Years (DALYs) attributable to diabetes were 70.9 million in 2019, and the direct healthcare burden of diabetes among adults worldwide was $966 billion in 2021. In this way, diabetes places a heavy burden on global public health and socioeconomic development [5, 6]. According to the IDF, China has one of the largest populations living with diabetes globally, and the prevalence of pre-diabetes and diabetes are on the rise, increasing from 3.23% to 2.51% in 1994 to 38.1% and12.4% in 2018 [8, 9].

The prevalence of diabetes and its associated costs and complications create a great need for diabetes self-management [3]. Diabetes self-management refers to the various daily behaviors that patients take to manage their diabetes to reduce the impact of diabetes on their physical health [10]. Diabetes self-management behaviors include regularly monitoring blood glucose, engaging in active physical activity, maintaining a healthy diet, taking diabetes medication, and having a good self-efficacy. These self-management behaviors reduce the risk of complications and improve psychosocial adjustment [11], and their significance in diabetes mellitus treatment is widely recognized [12], with growing evidence demonstrating that better diabetes self-management is associated with improved health outcomes [13, 14]. Nonetheless, studies have found that diabetes self-management is lacking in Chinese people with diabetes: only 9.2–16.7% perform self- management behaviors adequately [15–17].

A better understanding of the factors that contribute to prevalence and self-management of diabetes could allow for more targeted interventions to prevent and manage diabetes. In addition to diabetes risk factors such as being overweight or obesity and having a high calorie diet, research has also shown that higher individual-level socioeconomic status (SES) is associated with an increased risk for developing diabetes in low- and middle-income countries, but it is associated with a decreased risk for developing diabetes in high-income countries [18]. Furthermore [19, 20], studies have also found that factors that can impede effective diabetes self-management include development of diabetes early in life, being of a younger age, living in a rural region, being male, having established diabetes comorbidities, experiencing socioeconomic stress, and having a low level of health literacy, self-esteem, and familial support. In contrast, diabetes self-management is more effective among people living with diabetes with a higher education level as well as among those in the upper and middle socioeconomic classes [19, 20]. In China, higher SES was positively associated with diabetes, and these positive associations were even more pronounced in urban populations [21]. Several studies have also reported a positive relationship between higher educational level, household income level, and SES with better diabetes self-management [22, 23]. However, limited research has thus far been conducted to examine the relationships between SES and changes of diabetes prevalence and self-management in China, particularly in rural regions.

Yunnan Province, located in China's southwestern borderland, is one of the least economically developed regions of China. It has 129 official counties, and a population of 46.9 million, 22.7 million of whom are rural residents. The province is also home to the largest number of ethnic minorities in China, including 25 of the 56 ethnicities officially recognized by the Chinese government [24]. However, how diabetes prevalence and self-management changes over time, and the relationships between SES and changes in diabetes prevalence and self-management in these ethnic minority populations have not been identified. We suppose prevalence of diabetes and self-management behaviors shifted over time, and there would be significant socioeconomic differences in changes for the observed rates in Yunnan.

Thus, the purpose of the present study was to determine changes in pre-diabetes and diabetes prevalence and diabetes self-management behaviors in 2013 and 2022, and to investigate their relationships with socioeconomic factors.

Methods

Study area and population

The primary data in this study were collected from two community-based cross-sectional health interviews and examination surveys with independent samples conducted in three rural areas of Yunnan Province in 2012–2013 ($n = 7747$) and 2021–2022 ($n = 7536$) among individuals aged ≥ 35 years.

In 2013, all counties in Yunnan Province were classified into three categories according to their wealth distribution (per capita GDP): low, medium, or high. One county was then randomly selected from each of these categories for a total of three counties. A three-stage stratified random sampling method was then used to select study participants aged 35 years or older from the three selected rural counties. A detailed description of this sampling method has been published previously [25]. To select participants for the 2022 survey, a consistent three-stage stratified random sampling selection process was used in the same three rural counties.

Sample size calculation

The formula for a cross-sectional study was used to calculate the sample size for each selected village in each survey year: $n = z^2_{1-\alpha/2}\frac{(1-p)p}{\delta^2} \times deff$.

Where *deff* is the effect of design (*deff* = 2), p is the prevalence of diabetes in Chinese population, and δ is the margin of error (to estimate prevalence with a precision δ is equal to half of the prevalence of diabetes).

Data collection and measurement

In both 2013 and 2022, surveys were conducted face-to-face by uniformly trained investigators using an identical and pre-tested structured questionnaire to collect data on demographic characteristics (gender, age, ethnicity, household income, level of education), diagnoses, treatments, and self-management behaviors of diabetes, and family history of diabetes.

Fasting blood glucose (FBG), after a minimum overnight fast of 8 h, was also measured by a medical professional. The test used participant's a small drop of blood from a finger, and was measured by a blood glucose monitor machine (Qiang Sheng, Germany Healthcare Company). This technique had been validated against a standard test in the first affiliated hospital of Kunming Medical University. The detailed methodology has been previously reported [26].

Height, weight, and waist circumference (WC) were determined following the World Health Organization (WHO) STEPS manual [27]. Body mass index (BMI) was calculated as weight in kg divided by height in meters squared.

Definitions

According to WHO criteria [28], pre-diabetes or impaired glucose tolerance is defined as 6.1 mmol/L ≤ FBG < 7.0 mmol/L. Diabetes is defined as FBG ≥ 7.0 mmol/L, reported use of antidiabetic medications within the previous two weeks, and/or a reported previous diagnosis of diabetes by a health professional. Obesity was defined as a BMI of 28 kg/m^2 or greater, while central obesity was defined as a WC > 90 cm in males and > 80 cm in females, which is in line with WHO recommendations for Asian adults [29].

Among study participants with diabetes, taking measures to control diabetes was defined as having taken at least one of the following actions in the two weeks prior to the survey: losing weight, eating a special diet, increasing exercise levels, and quitting smoking.

In our study, ethnic minorities refer to the Yi, Naxi, and Lisu peoples. Participants were divided into two educational groups, those with any formal education and those with no formal education. Participants were categorized by income into two annual household income groups, low or high, with the median income as the cut-off point. Participant access to medical services was defined into two groups according to walking distance from their homes to the nearest village medical center; less than 30 min was defined as good access, and 30 min or more was defined as poor access.

Statistical analysis

Data were entered into an EpiData Entry 3.1 database in duplicate and analyzed with SPSS 22.0 software. Descriptive statistics were calculated such that categorical variables were presented as counts and percentages, while continuous variables were presented as mean ± standard deviation (SD). To assess the differences in categorical variables between survey years, a Chi-squared test was utilized, while t-test analysis was employed for continuous variables. Prevalence of pre-diabetes and diabetes were adjusted for age by direct standardization to the 2020 Chinese population aged ≥ 35 years. Logistic regression was used to analyze the association between individual SES variables (educational level, annual household income, access to medical services, and SEP) and the prevalence of pre-diabetes and diabetes and rates of self-management behaviors of diabetes, adjusted by sex, age, ethnicity, obesity, central obesity, and family history of diabetes. Associations were expressed as odds ratios and 95% CI. Two-tailed P values were used to determine statistical significance, with $p < 0.05$ considered statistically significant.

Principal component analysis (PCA) was used to develop a composite index for measuring socioeconomic position (SEP). This analysis incorporated the three key individual socioeconomic indicators determined to be

most correlated across three socioeconomic dimensions, based on an estimated Pearson correlation index > 0.5: education, annual household income, and access to medical services. Bartlett's test of sphericity was used to assess the adequacy of correlations between indicators, with a significance criterion of $P < 0.0001$. Additionally, the sample adequacy was evaluated using the Kaiser-Meyer-Olkin (KMO) statistic, with a threshold of ≥ 0.7. Based on the scree plot examination, principal components were extracted using the Kaiser criterion of eigenvalues ≥ 1.

Results

A total of 8,400 and 7,800 individuals aged ≥ 35 years were recruited to participate in the surveys conducted in 2012–2013 and 2021–2022, respectively. Of these, 7,747 participants in 2012–2013 and 7,536 participants in 2021–2022 gave consent to participate and completed the surveys. This resulted in overall response rates of 92.2% in 2013 and 96.6% in 2022.

Table 1 General characteristics of the study population by survey year

Variable	Survey year		*P*
	2013	2022	
	% / $\bar{X} \pm S$	% / $\bar{X} \pm S$	
Sex			0.608
Male	49.0%	49.4%	
Female	51.0%	50.6%	
Age			< 0.001
35–44 years	26.7%	11.1%	
45–54 years	26.7%	22.8%	
55–64 years	23.6%	25.9%	
65–74 years	15.0%	24.4%	
≥75 years	8.0%	15.8%	
Ethnicity			< 0.001
Han	59.2%	53.0%	
Minority	40.8%	47.0%	
Education			0.706
No formal education	19.0%	19.3%	
Any formal education	81.0%	80.7%	
Annual household income			< 0.001
Low	40.2%	49.3%	
High	59.8%	50.7%	
Access to medical services			0.001
Poor	32.4%	35.0%	
Good	67.6%	65.0%	
SEP			< 0.001
Low	41.0%	52.1%	
High	59.0%	47.9%	
FBG (mmol/l, mean ± SD)	5.81 ± 1.62	5.55 ± 1.77	< 0.001
Height (cm, mean ± SD)	159.89 ± 8.12	159.07 ± 8.75	< 0.001
Weight (kg, mean ± SD)	57.64 ± 10.22	58.65 ± 11.30	< 0.001
BMI (kg/m2, mean ± SD)	22.49 ± 3.34	23.10 ± 3.58	< 0.001
WC (cm, mean ± SD)	79.79 ± 9.53	81.90 ± 10.06	< 0.001

BMI = body mass index

WC = waist circumference

FBG = fasting blood glucose

SD = standard deviation

Results of both the PCA with Bartlett's test ($P < 0.0001$) and KMO Measure (0.71) showed correlations between indicators that were sufficiently large to perform the PCA. Only the first component with eigenvalues > 1 produced a three-component rotated solution that explained 47.1% of the total variance in the data. The component score coefficient of education, annual household income, and access to medical services was 0.68, 0.68, and 0.56, and the low and high value of SEP index score was − 1.84 and 1.55, respectively. Consequently, only one component was retained to define the SEP index, and the SEP index was then further categorized into two levels, low or high, with the median value as the cut-off point.

As shown in Table 1, the proportion of men and participants with a low level of education among the study participants did not differ between the two survey years ($P > 0.05$), while the proportion of ethnic minority participants and proportion of participants with a low annual household income, poor access to medical services, and low SEP was higher in 2022 than in 2013 ($P < 0.05$).

Table 2 presents age-standardized prevalence of pre-diabetes and diabetes by survey year and socioeconomic status in rural Yunnan Province, China. The prevalence of new diagnosed vs. known diabetes was 3.8% and 3.7% in 2013, while was 2.5% and 5.8% in 2022, respectively. In 2022, the overall age-standardized prevalence of pre-diabetes and diabetes were 15.7% and 7.6%, respectively, which were lower than those in 2013 (18.3% and 8.2%) ($P < 0.05$) (Fig. 1). This change was also observed in women, individuals aged 45–54 years, Han ethnicity participants, and participants with a high educational level, high annual household income, good access to medical services, and high SEP ($P < 0.05$). However, the prevalence of pre-diabetes and diabetes was higher in 2022 compared to 2013 among ethnic minorities and those with low annual household income and low SEP. Further, the prevalence of diabetes was also higher in 2022 than in 2013 among individuals with poor access to medical services. While pre-diabetes levels in 2013 did not differ by gender, the prevalence of pre-diabetes in 2022 was higher in men than in women ($P < 0.01$). And in 2013, a correlation between Han ethnicity, high educational level, high annual household income, good access to medical services, and high SEP with higher prevalence of pre-diabetes was observed ($P < 0.01$). Additionally, in both 2013 and 2022, Han ethnicity participants, individuals with high annual household income, and individuals with good access to medical services and high SEP had a higher prevalence of diabetes than their counterparts ($P < 0.01$).

Table 2 Age-standardized prevalence of pre-diabetes and diabetes by survey year and socioeconomic status in rural Yunnan Province, China

Characteristic	Pre-diabetes			Diabetes		
	2013	2022	*P*	2013	2022	*P*
All	18.3%	15.7%	0.033	8.2%	7.6%	0.039
Sex						
Male	19.0%	17.3%*	0.858	8.7%	8.0%	0.708
Female	17.6%	14.1%	0.012	7.6%	7.5%	0.030
Age						
35–44 years	12.7%*	10.2%*	0.053	3.6%*	4.1%*	0.581
45–54 years	17.8%	13.0%	< 0.001	6.1%	6.4%	0.719
55–64 years	18.8%	18.4%	0.719	9.5%	8.6%	0.380
65–74 years	21.6%	19.4%	0.130	11.9%	11.2%	0.539
≥75 years	21.6%	18.1%	0.071	10.8%	8.8%	0.165
Ethnicity						
Han	21.9%*	16.3%	< 0.001	11.0%*	9.4%*	0.640
Minority	12.8%	14.8%	< 0.001	3.9%	6.0%	< 0.001
Education						
No formal education	15.9%*	16.2%	0.179	7.8%	8.6%	0.126
Any formal education	19.1%	15.5%	0.008	8.3%	7.5%	0.218
Annual household income						
Low	14.1%*	15.4%	0.005	6.0%*	7.4%*	0.001
High	21.3%	15.8%	< 0.001	9.8%	8.1%	0.874
Access to medical services						
Poor	17.5%*	16.0%	0.710	5.4%*	6.7%*	< 0.001
Good	18.7%	15.5%	0.013	9.5%	8.3%	0.999
SEP						
Low	14.8%*	15.5%	0.017	5.6%*	7.0%*	< 0.001
High	20.8%	15.8%	< 0.001	10.0%	8.5%	0.959

*$P < 0.05$, comparison of different characteristics within the same year

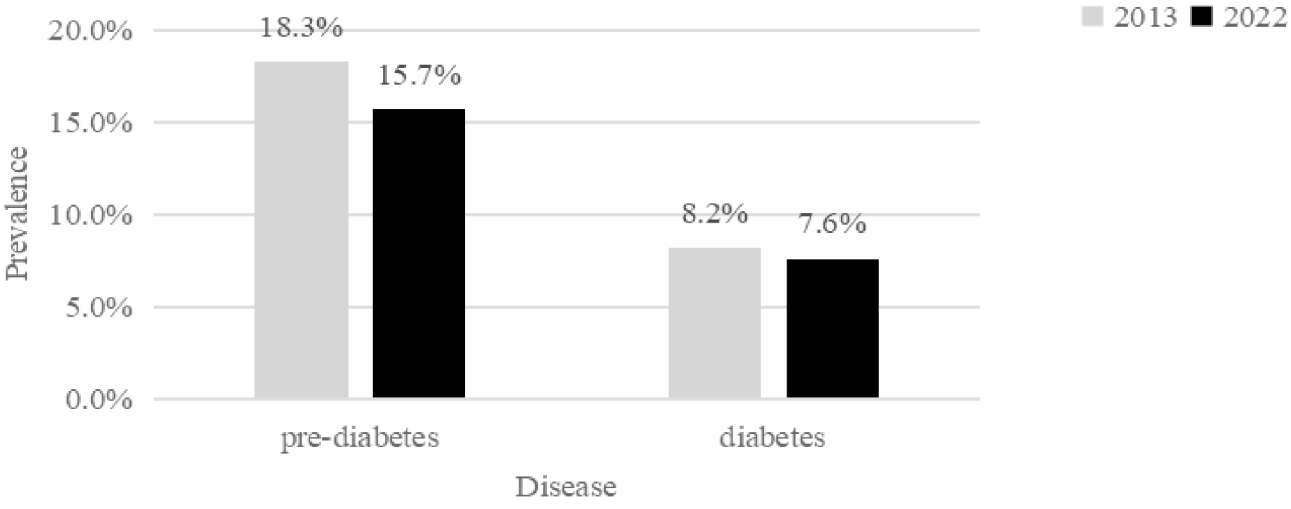

Fig. 1 Age-standardized prevalence of pre-diabetes and diabetes by survey year

Table 3 presents the rates of self-management behaviors among participants living with diabetes by survey year and socioeconomic status in the present study. In 2022, the overall rate of compliance with anti-diabetes medications or insulin injection in the 12 months prior to the survey was 95.9%, which was higher than the rate in 2013 (76.5%), while the overall rate of having taken measures to control diabetes in the two weeks prior to the survey was 39.7%, which was lower than the rate in 2013 (53.3%) ($P < 0.01$) (Fig. 2). This change of compliance with anti-diabetes medications or insulin injections was also observed among the subgroups categorized by sex,

Table 3 Rates of self-management behaviors among participants living with diabetes by survey year and socioeconomic status in rural Yunnan Province, China

Characteristic	Compliance with anti-diabetes medications or insulin injections in the past 12 months			Regular blood glucose self-monitoring in the prior 12 months			Taking measures to control diabetes in the prior two weeks		
	2013	2022	*P*	2013	2022	*P*	2013	2022	*P*
All	76.5%	95.9%	< 0.001	41.8%	44.7%	0.427	53.3%	39.7%	< 0.001
Sex									
Male	77.4%	94.9%	< 0.001	50.7%*	49.7%	0.863	58.9%	44.2%	0.007
Female	75.5%	96.7%	< 0.001	32.4%	40.7%	0.108	47.5%	36.1%	0.029
Age									
35–44 years	68.0%	83.3%	0.256	60.0%	61.1%	0.941	44.0%	50.0%	0.697
45–54 years	78.2%	95.8%	0.002	36.4%	50.7%	0.108	54.5%	45.1%	0.291
55–64 years	79.8%	95.7%	< 0.001	46.5%	45.3%	0.864	54.5%	51.3%	0.632
65–74 years	77.8%	96.4%	< 0.001	41.7%	46.1%	0.532	55.6%	32.7%	0.001
≥75 years	67.6%	98.5%	< 0.001	23.5%	29.9%	0.502	50.0%	28.4%	0.032
Ethnicity									
Han	81.0%*	97.7%*	< 0.001	43.1%	45.6%	0.559	53.7%	30.7%*	< 0.001
Minority	62.3%	91.5%	< 0.001	37.7%	42.6%	0.499	52.2%	61.2%	0.218
Education									
No formal education	67.6%*	95.0%	< 0.001	22.5%*	39.6%	0.019	50.7%	22.8%*	< 0.001
Any formal education	79.4%	96.1%	< 0.001	48.1%	46.3%	0.673	54.2%	44.8%	0.031
Annual household income									
Low	72.8%	96.4%	< 0.001	29.1%*	41.7%	0.034	56.3%	39.6%	0.006
High	78.6%	95.5%	< 0.001	48.9%	47.2%	0.721	51.6%	39.8%	0.015
Access to medical services									
Poor	63.1%*	94.0%	< 0.001	27.7%*	42.1%	0.049	44.6%	39.8%	0.523
Good	80.5%	96.7%	< 0.001	45.9%	45.9%	0.999	55.9%	39.7%	< 0.001
SEP									
Low	66.3%*	94.6%	< 0.001	27.9%*	41.7%	0.018	47.1%	38.2%	0.134
High	82.3%	97.0%	< 0.001	49.7%	47.4%	0.644	56.9%	41.0%	0.001

*$P < 0.05$, comparison of different characteristics within the same year

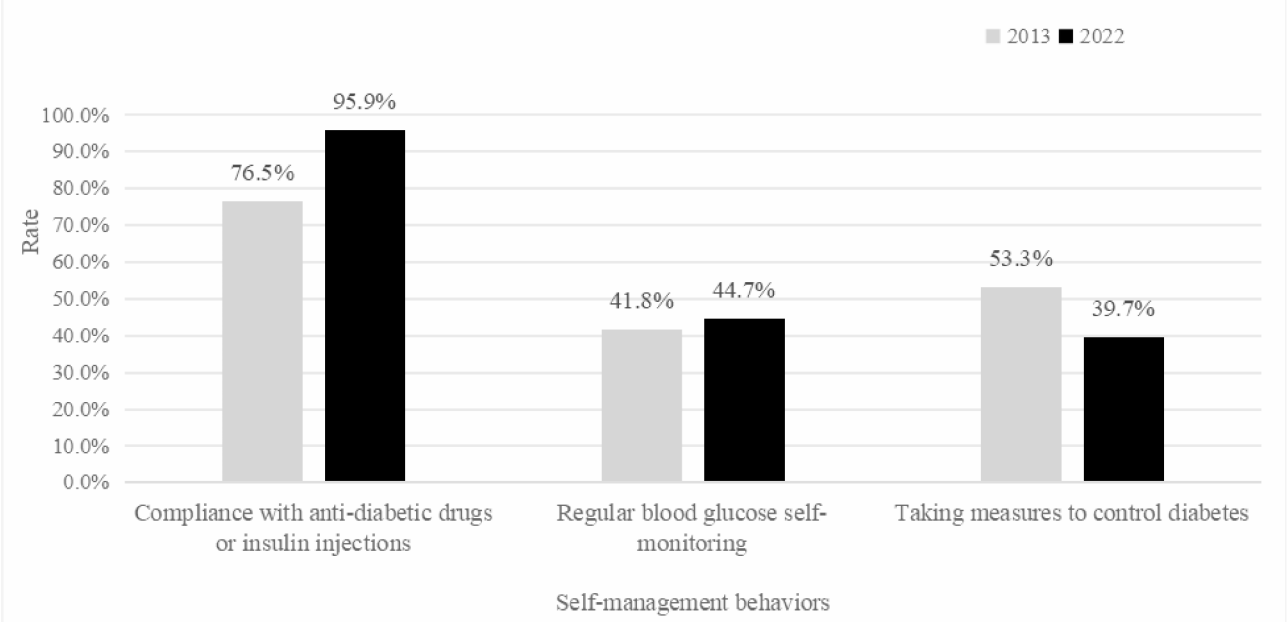

Fig. 2 Rates of self-management behaviors among participants living with diabetes by survey year

age (except for those aged 35–44 years), ethnicity, education level, income level, access to medical services, and SEP ($P<0.05$). However, in 2022, a lower rate of taking measures to control diabetes was observed among subgroups categorized by sex, education, income level, Han ethnicity, good access to medical services, and high SEP ($P<0.05$). Furthermore, while the overall rate of regular self-monitoring of blood glucose did not differ between the two survey years ($P>0.05$), a higher rate of regular blood glucose self-monitoring was observed among individuals with low education level and annual household income, those with poor access to medical services, and participants with low SEP ($P<0.05$) in 2022. In both 2013 and 2022, compliance with anti-diabetes medications or insulin injections was higher among Han ethnicity participants than among ethnic minorities ($P<0.01$). In 2013, participants with higher education, better access to medical services, and higher SEP had higher rates of compliance with anti-diabetes medications or insulin injections and regular blood glucose self-monitoring than their counterparts ($P<0.05$). Additionally, men and participants with higher annual household incomes also had higher rates of regular blood glucose self-monitoring than their counterparts ($P<0.05$), and regular blood glucose self-monitoring decreased with age ($P<0.05$). In 2022, ethnic minorities and participants with higher education levels took measures to control diabetes at higher rates than their counterparts, and the rate of taking measures to control diabetes decreased with age ($P<0.01$).

Table 4 indicates the results of multivariate logistic regression analysis of prevalence of pre-diabetes and diabetes by survey year and socioeconomic status after adjusting for sex, age, ethnicity, obesity, central obesity, and family history of diabetes. In 2013, Individuals with higher educational level and higher annual household income, good access to medical services, and higher SEP were more likely to be suffered from pre-diabetes ($P<0.05$), while in both 2013 and 2022, individuals with higher annual household income and individuals with good access to medical services were more likely to be suffered from diabetes ($P<0.01$).

Table 5 presents the results of multivariate logistic regression analysis of rates of self-management behaviors of diabetes by survey year and socioeconomic status after adjusting for sex, age, ethnicity, obesity, central obesity, and family history of diabetes.

In 2013, education level, access to medical services, and SEP level were positively associated with compliance with anti-diabetes medications or insulin injections and regular blood glucose self-monitoring ($P<0.05$). Furthermore, annual household income was also positively associated with regular blood glucose self-monitoring ($P<0.05$). In 2022, education level was positively associated with taking measures to control diabetes ($P<0.01$).

Discussion

The present study's findings indicate that both the prevalence of pre-diabetes and diabetes and the rate of self-management behaviors among participants living with diabetes shifted over time: the rural Chinese adult population had a lower prevalence of pre-diabetes and diabetes and a lower rate of taking measures to control diabetes in 2022 than in 2013, while they had a higher rate of compliance with anti-diabetes medications or insulin injections in 2022 than in 2013. Further, this study also uncovered significant socioeconomic differences in the changes for these observed rates.

The overall prevalence of pre-diabetes and diabetes (15.7% and 7.6%) in the study population in 2022 was lower than the prevalence rates observed in other Asian populations, including India (17.4% and 15.0%) [30], Iran (20.6% and 17.4%) [31], Vietnam (52.9% and 11.4%) [32], Sri Lanka (18.5% and 21.8%) [33], and a national Chinese study (38.1% and 12.4%) [9]. Moreover, the data revealed that both the prevalence of pre-diabetes and diabetes in rural southwest China in 2022 was lower than in 2013,

Table 4 Logistic regression for prevalence of pre-diabetes and diabetes by survey year and socioeconomic status in rural Yunnan Province, China

Characteristic	Pre-diabetes		Diabetes	
	2013	2022	2013	2022
	Adjusted odds ratio† (95% CI)	Adjusted odds ratio† (95% CI)	Adjusted odds ratio† (95% CI)	Adjusted odds ratio† (95% CI)
Level of education (reference: No formal education)	1.22* (1.02, 1.45)	1.04 (0.88, 1.23)	0.95 (0.74, 1.22)	0.99 (0.80, 1.25)
Annual household income (reference: Low)	1.73** (1.52, 1.97)	1.06 (0.94, 1.21)	1.87** (1.54, 2.28)	1.16* (1.01, 1.34)
Access to medical services (reference: Poor)	1.23* (1.03, 1.47)	0.92 (0.81, 1.05)	1.43** (1.15, 1.77)	1.12* (1.01, 1.29
SEP (reference: Low)	1.26** (1.09, 1.45)	1.01 (0.87, 1.17)	1.44** (1.16, 1.80)	1.02 (0.84, 1.24)

*$P<0.05$, **$P<0.01$, † adjusted for age, sex, ethnicity, obesity, central obesity, and family history of diabetes

Table 5 Logistic regression for rates of self-management behaviors among participants living with diabetes by survey year and socioeconomic status in rural Yunnan Province, China

Characteristic	Compliance anti-diabetes medications or insulin injections in the past 12 months		Regular blood glucose self-monitoring in the prior 12 months		Taking measures to control diabetes in the prior two weeks	
	2013	2022	2013	2022	2013	2022
	Adjusted odds ratio† (95% CI)	Adjusted odds ratio† (95% CI)	Adjusted odds ratio† (95% CI)	Adjusted odds ratio† (95% CI)	Adjusted odds ratio† (95% CI)	Adjusted odds ratio† (95% CI)
Level of education (reference: No formal education)	1.43* (1.07, 2.78)	1.99 (0.57, 6.96)	2.65** (1.36, 5.17)	1.04 (0.64, 1.71)	1.05 (0.58, 1.87)	2.48** (1.41, 4.38)
Annual household income (reference: Low)	1.21 (0.67, 2.21)	0.60 (0.22, 1.66)	2.14** (1.23, 3.74)	1.21 (0.82, 1.79)	0.77 (0.46, 1.28)	1.16 (0.76, 1.77)
Access to medical services (reference: Poor)	1.88* (1.04, 3.64)	1.71 (0.63, 4.64)	1.80* (1.03, 3.50)	1.14 (075, 1.73)	1.69 (0.93, 3.07)	1.08 (0.69, 1.69)
SEP (reference: Low)	1.99* (1.06, 3.77)	1.12 (0.36, 3.51)	2.41** (1.34, 4.34)	1.12 (0.73, 1.73)	1.49 (0.86, 2.58)	1.91 (0.52, 3.11)

*$P < 0.05$, **$P < 0.01$, † adjusted for age, sex, ethnicity, obesity, central obesity, and family history of diabetes

which is neither in line with prior changes observed in China [34] nor with global pre-diabetes and diabetes changes [8]. The observed change in our study can be either attributed to the effectiveness of prevention and control strategies, resulting in a reduction in the prevalence of pre-diabetes and diabetes, or a result of an aging population and suboptimal medical practices, leading to increased mortality rates among individuals with diabetes. A previous study found a significant increase in age-standardized diabetes mortality in Yunnan Province [35]. Moreover, in our research, prevalence of obesity, central obesity, and physical inactivity was higher in 2022 than in 2013, and obesity, central obesity, and physical inactivity are well-documented major risk factors for diabetes.

In this study, ethnicity, level of annual household income, and access to medical services had apparent impacts on prevalence of diabetes. The prevalence of diabetes was higher in the Han ethnicity than in the ethnic minority participants in both 2013 and 2022, which aligns with ethnic differences in diabetes previously documented in China [34, 36]. These ethnic differences may result from differing lifestyles in ethnic minority communities [36] and the genetic predisposition of the Han ethnicity [37]. Further, the fact that diabetes was more prevalent in participants with high annual household income, and with good access to medical service and high SEP in both 2013 and 2022, which line with findings from our country and other developing nations [18, 38], despite experiencing swift economic growth, our country remains a developing one. Individuals with high SEP face a heightened risk of diabetes, a consequence of the substantial rise in obesity and physical inactivity rates.

The present study also uncovered ethnic and SEP differences in the changes in pre-diabetes and diabetes prevalence. A lower prevalence of pre-diabetes was observed among Han ethnicity and those with a high educational level, high annual household income, good access to medical services and high SEP in 2022 than in 2013, whereas a higher prevalence of prediabetes and diabetes was observed among ethnic minorities and those with low annual household income and low SEP in 2022 than in 2013. These suggest that as the local social economy advances, the diabetes epidemic is moving from Han ethnicity and people with high SEP to ethnic minorities and people with low SEP. And we also observed that the prevalence of obesity, central obesity, and physical inactivity was notably higher among ethnic minorities and individuals with low SEP in 2022 than in 2013. The results thus suggest future diabetes prevention and control strategies should focus in particular on ethnic minorities and individuals with low socioeconomic position to head off the emerging diabetes epidemic.

The present study also indicated different changes of various self-management behaviors among participants living with diabetes in this study region. Compared to 2013, in 2022 the compliance rate with anti-diabetes medications and insulin injections was higher, while the rate of taking measures to control diabetes was lower. However, the rate of regular blood glucose self-monitoring did not differ. Moreover, among these rates, the compliance rate with anti-diabetes medications and insulin injections was the highest, while the rate of taking measures to control diabetes was the lowest, which is consistent with previous studies [39, 40]. The observed disparity could be associated with economic obstacles faced by patients and the inconsistent availability of diabetes management services. The blood glucose monitoring equipment and test strips can impose a significant financial

strain on patients, and fear of needles may also be a barrier of self-monitoring of blood glucose among patients. Furthermore, despite patients have access to free lifestyle guidance, their execution of glycemic control measures remains poor due to insufficient health awareness and self-efficacy [41]. However, with the implementation of the "Zero Mark-up Medicines" and "Chronic Disease Outpatient Compensation" policies, patients can pay less to obtain medications for diabetes treatment [42]. Therefore, it is emphasized that patients should be given more economic and health promotion support to improve their self-monitoring of blood glucose and adherence to glycemic control measures.

Our study indicated a strong relationship between individual SES and changes of self-management behaviors among participants living with diabetes. Compared to 2013, in 2022, the rate of compliance with anti-diabetes medications or insulin injections was higher significantly across the entire SES spectrum, with the largest relative high occurring among participants with low level of education, low level of income, poor access to medical services, and low SEP. Although overall rates of taking measures to control diabetes was lower, the rate did not differ among ethnic minority patients, participants with poor access to medical services and those with low SEP. Further, despite the fact that the overall rate of regular blood glucose self-monitoring did not differ between the two survey years, a higher rate was observed among patients with a low education level, low annual household income, poor access to medical services, and low SEP. These findings suggest that diabetes self-management behaviors have been successfully improved among patients with low SES in rural southwest China, and this success can be attributed to the national basic public health services' objective of ensuring accessibility and equality for all services [43].

The present study has several limitations. First, only FBG was used to diagnose pre-diabetes and diabetes. Hemoglobin A1C was not measured. Thus, the prevalence of pre-diabetes and diabetes may be underestimated. Second, self-management behaviors of diabetes were based on patient recall, and may therefore be subject to bias and affect the accuracy of the frequency and type of self-management behaviors recorded. Third, diet, physical activity level, or hypercholesterolemia data were not included in our multivariate analysis, and they could be important factors in influencing the prevalence of diabetes. Therefore, the contributory effects of the socio-economic factors may be overestimated. Fourth, the present findings were based on a random sampling of three Yunnan counties, and we were unable to obtain data on the total population of Yunnan Province stratified by education, income, and SEP. Consequently, we could not perform weighted analyses on the data, which may limit the generalizability of the results to all rural regions in Yunnan Province.

Conclusions

In conclusion, there was no significant difference in the prevalence of prediabetes across levels of education and income, while individuals with higher incomes were more likely to develop diabetes in 2022. Further, the prevalence of pre-diabetes and diabetes as well as diabetes self-management behaviors changed in rural southwest China over the nine-year study period, and socioeconomic differences are varyingly associated with changes for the observed rates. Future interventions to further control diabetes and improve diabetes self-management behaviors must be tailored to address socioeconomic disparities.

Abbreviations

FBG	Fasting blood glucose
GDP	Gross Domestic Product
KMO	Kaiser-Meyer-Olkin
PCA	Principal Components Analysis
SEP	Socioeconomic position
SES	Socioeconomic status

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Author contributions

XW carried out the study and drafted the manuscript. LC designed the study and revised the manuscript. GHL, LL and YZ collected the data. HFL and ARG provided comments on the paper during the writing process. All authors have read and approved the manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Kunming Medical University prior to the commencement of research. Written informed consent was obtained from all study participants in both survey years.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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