Childhood Socioeconomic Status and Type 2 Diabetes Mellitus among Mid-late Chinese: A Structural Equation Modeling Analysis

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Research

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Abstract

Objectives This present study was aimed to examine the associations between childhood socioeconomic status (CSES) and type 2 diabetes mellitus (T2DM) among mid-late Chinese and disentangle the pathways using structural equation modelling (SEM).

Methods Using cross-sectional data from China Health and Retirement Longitudinal Study (CHARLS), this study included 19767 participants aged 45 and over. SEM models were constructed to decompose the intricate relationships between CSES, childhood health history (CHH), adulthood socioeconomic status (ASES), health-related behaviors (HRB) and T2DM.

Results The results showed that T2DM was significantly associated with CSES (sβ = -0.239; P = 0.001), CHH (sβ = -0.016; P = 0.005) and ASES (sβ = -0.180; P = 0.002) directly, While the indirect effect of CSES on T2DM was sβ = -0.111; P = 0.001with an acceptable goodness-of-fit. The model presented an acceptable goodness of fit: RMSA0.082, CFI 0.803, GFI 0.938, AGFI 0.904, and SRMR 0.060.

Conclusions CSES had direct and indirect effects on later incidence of T2DM, which was mediated by ASES and CHH, supporting the life course theory, indicating that optimal interventions should be conducted in the early stages of life to narrow the socioeconomic and obtain maximal health benefits.

Background

Type 2 diabetes mellitus (T2DM) has emerged as a major global public health concern, which directly led to almost 1.6 million deaths and became the top 10 global causes of death in 2016, with the prevalence of T2DM rising sharply to 422 million in 2014 and rapid increase of incidence especially in middle- and low-income countries. Genetic inheritance and dietary behaviors are known important risk factors of T2DM (1), furthermore, disadvantaged socioeconomic circumstance, which is commonly characterized by meager income, low levels of education and occupation, has also been reported to be associated with higher risk of T2DM (2), suggesting that socioeconomic inequities in the incidence of T2DM. Increasing studies have given insights into socioeconomic factors for the potential “long-term” effects on biological, psychological and behavioral factors of T2DM and attached great importance to childhood socioeconomic status (CSES) over the life course (3). Disadvantaged CSES have been revealed as a salient predictor of later health, which is associated with majority chronic diseases occurring in mid-late adulthood such as cardiovascular disease (4), hypertension (5), functional limits (6), stroke (7) and cognitive impairment (8).

In view of the morbidity and mortality of T2DM, studies into potential contributing factors and pathogenic pathway are in great needs, one understudied area that merits attention is the potential pathway between CSES and T2DM (9). The association between CSES and T2DM may be mediated by adult socioeconomic status (ASES), as previous studies have addressed the association between ASES and T2DM (2), trajectory of socioeconomic circumstances over the life course has also been reported in association with the incidence of T2DM in a latest study (10). Limited studies yielded mixed results for

the association (11, 12). Lidfeldt et al found father's occupation was associated with T2DM among mid-late American nurses (13), and Goodman revealed levels of parental education were important risk factors in the Princeton School District Study (14).

Life course health development (LCHD) theory is suitable for this study to decompose the effects and pathways of socioeconomic conditions over the life course on affecting the incidence of T2DM and try to trace origins of T2DM during childhood, which integrated behavioral, biological and psycho-social factors and comprised three conceptual models: the sensitive period model, the pathway model and social mobility model that not mutually exclusive (15). Disparities in CSES might propel unequal life-course trajectories in various aspects including ASES and negative health outcomes across the lifespan (16). The sensitive period model assumes that adverse exposures during specific and sensitive periods of life course (e.g. childhood) may have long-lasting effects on the development of physiology, psychology and health-related behaviors by biological scarring and imprinting, and thereby increase the susceptibility to negative health problems in mid-late adulthood (15). Exposures experienced in adulthood might modify the effect of biological programming on the development of chronic diseases such as T2DM (10). Supporting the sensitive period model, low CSES has been reported to be inversely associated with metabolic disorders, and the association was attenuated after adjusting for later exposures (17). The pathway model, also referred as "chains-of-risk" model or accumulation of risk model, hypothesizes that advantageous and disadvantageous childhood experiences are consequential for driving the life-course trajectories an then manifest in positive or negative health outcomes (15), which focuses on the pathways and the accumulated exposures through the life course related to later health (15). The pathway model posits that CSES could trace socioeconomic trajectories into adulthood which are risk factors of T2DM, indicating that the influence of childhood hardships on later health may be mediated via certain experiences such as ASES. Studies within the LCHD perspective have revealed that the sensitive and critical time window, duration and frequency of exposure to social stressors may impact the incidence of T2DM (18). Social mobility model highlights the effects of social shifts between intra-and-inter generations across the life course, assuming that steady poor socioeconomic circumstance and downward socioeconomic shifts both are detrimental to health, while upward shifts are associated with health positively (19). As regards the social mobility model, descending and stable poor socioeconomic circumstance from early stage of life to later adulthood were linked to higher risk of T2DM compared with stable high socioeconomic circumstances (20). In view of LCHD theoretical framework, multifaceted and cumulated exposures across the lifespan cause direct and indirect effects between CSES and T2DM, and childhood health history (CHH), ASES and health-related behaviors (HRB) may mediate the effect of exposures lead to standing consequences in later adulthood (10).

Minimizing collinearity with confounding indictors, methodological challenges exist in decomposing the direct and indirect effects of CSES and most studies only concentrate on the direct relationship between a single outcome with several predictors employing common regression models (21). It is appropriate to apply structural equation modeling (SEM) incorporating multiple factors in this study to identify underlying pathways and disentangle the direct and indirect effects between CSES and T2DM within the LCHD conceptual framework. Compared to common regression models which are limited in disentangling

indirect effects between CSES and T2DM, SEM enables to estimate such effects with multiple pathways and helps to study mechanisms intensively to propose optimal interventions in the critical and sensitive period of life (21). Furthermore, previous studies have evidenced that SEM is useful to interpret and understand the underlying mechanisms of life course, which is helpful to construct social policies to improve later risks of T2DM through alleviation of disadvantaged CSES (21).

However, robust evidence on the childhood origins of later T2DM remains unclear. Limited studies examining the effect of CSES over the life course in middle-income countries such as china, it is considerate to explore how the disadvantaged CSES propel the trajectory. Considering the huge epidemic and demographic transitions, there are implications for dealing with the severe aging situation in China rising with aging population (22).

Given the specific context in china and the established evidence of T2DM, the aim of this study was to examine the complex effects and pathways between CSES and T2DM using SEM, which proposed the hypothesized conceptual model in Fig. 1, comprising CSES and other potential indicators that may related to T2DM. By illustrating pathways within the life course perspective, this study provided new insights into programming the optimal interventions in the most appropriate stages through the life course to narrow the socioeconomic health disparities and obtain maximal health benefits.

Methods

Study design and participants

The data used in this study was taken from China Health and Retirement Longitudinal Study (CHARLS) conducted in 2014 and 2015, which was a large national population-based survey of Chinese aged 45 and older, conducted by the Centre for Healthy Aging and Family Studies at Peking University (22–24). CHARLS adopted a four-stage stratified sampling, covering about 150 counties or districts and 450 villages/residential communities in 28 out of 32 provinces across mainland China (23). Details of the CHARLS have been well documented previously (22, 23). The CHARLS project was approved by the Biomedical Ethics Committee of Peking University, each participant provided a written informed consent.

2014 wave of CHARLS was a special life history survey, which retrospectively collected information about participants' health history and family conditions during childhood, including the measures of CSES and CHH conditions (22). Notably, this data defined the childhood as a period below first 16 years (16). 2015 wave was a regular survey collecting social-demographic characteristics, health-related behaviors (HRB) and self-reported chronic diseases of participants. The data of wave 2014 and 2015 was combined based on participants' IDs to trace the CSES, CHH, ASES, HRB and self-reported status of T2DM. Wave 2014 and 2015 included 20,948 and 21,789 participants respectively, which were excluded if under the age of 45 or had missing value on outcomes. After combination and exclusion, finally 19767 participants remained in this study.

Measures

Outcome

The primary outcome was based on self-reports of doctor-diagnosed T2DM, the responses of participants were divided into yes or no.

Predictors

Data regarding CSES was obtained from the 2014 wave of CHARLS, which was comprised by four indicators: (a) father's schooling years (0 year, 1–6 years, 7–12 years or > 12 years); (b) mother's literacy status (illiterate or literate); (c) father's occupation (farming vs non-agricultural); (d) mother's occupation (farming vs non-agricultural), which were typically indicators based on previous literature (22). CHH was also extracted from wave 2014 comprising four indicators: (a) self-rated childhood health status (much healthier, somewhat healthier, about average, somewhat less healthy or less healthy); (b) confined to bed or home because of health conditions during childhood (yes or no); (c) hospitalized for a month or more during childhood (yes or no); (d) hospitalized more than three times before 16 years (yes or no).

ASES included 2 indicators obtained from wave 2015 of CHARLS: (a) residential area (rural or urban); (b) years of schooling (0 year, 1–6 years, 7–12 years and > 12 years).

HRB was measured using 2 indicators: (a) smoking status (past smokers, current smokers or non-smokers); (b) alcohol drinking habits (drink more than once a month, drink less than once a month or never drinking).

Statistical analyses

Descriptive statistics of the participants' characteristics were presented as means ± standardized deviation and percentages. Student's t-test for continuous variables, Chi-Square tests or Fisher's Exact tests for categorical variables were employed to compare characteristics between participants with and without T2DM.

SEM is a statistical technique for elaborating complex relationships, pathways and interactions between one or more predictors and outcomes, which was performed to examine the underlying associations and life-course mechanisms linking CSES, CHH, ASES, HRB to T2DM in later adulthood (25, 26). Path analyses were conducted based on the hypothesized model (Fig. 1), which is developed according to the conceptual framework of LCHD theories. Estimates of direct, indirect and total effects (the sum of direct and indirect effects) of each component on T2DM were computed and recorded in the final model (27), the statistical significance of which was confirmed by using the bootstrapping method (28). In this study, SEM was applied to estimate a direct pathway from CSES (independent) to T2DM (dependent), and potential indirect pathways through mediating components: CHH, ASES and HRB. Different Goodness-of-Fit indices including 1) The Standardized Root Mean Square Residual (SRMR), the Root Mean Square Error of Approximation (RMSEA) and the Akaike Information Criterion (AIC); 2) the Goodness-of-Fit Index (GFI) and the Adjusted Goodness-of-Fit Index (AGFI); and 3) Comparative Fit Index (CFI) were estimated to assess the best fitting models (29). SRMR, RMSEA, GFI, and AGFI are absolute fit indices indicating to

what extent the hypothesized model fit the sample data, while CFI is an incremental fit index indicating the proportional improvement in fit (30). Recommended by prior literature (31, 32), RMSEA < 0.10, SRMR < 0.80, CFI 0.80, GFI and AGFI ≥ 0.90 indicate an acceptable model fitness. Though the χ2 values should have been reported as one of the fit index, it were excluded as being highly sensitive to large sample sizes and often inflated with non-normal data such as PA data (33, 34).

This study rebuilt the final SEM models by removing some non-significant associations and re-assessing the hypothesized model fitness,where the standard coefficients (sβ) and P values were calculated and reported. P values less than 0.05 was considered as statistical significance for all analyses. Descriptive statistics were computed using Stata 14.0 (Stata Corp; College Station, TX, USA), and SEM analyses were performed using AMOS (version 23.0).

Results

Study characteristics

Table 1 presents the descriptive statistics for the study characteristics of the full sample. The mean age of the full sample was 60.64 ± 9.64 years, and almost half of the participants were female (48%). The total prevalence of T2DM in the whole sample was 2.58%. CSES, CHH, ASES and HRB indictors were all significantly different between participants with and without T2DM (P < 0.05). There was no difference in sex between participants with and without T2DM (P = 0.426).

Table 1
study characteristics of the full sample (N = 19767)

Variables	Overall	T2DM		χ^2	P value
		No	Yes		
CSES					
Father's education attainment				608.503	< 0.001
> 12 years	153	153	0		
7–12 years	1255	1255	0		
1–6 years	9170	8658	512		
0 year	9189	9188	1		
Mother's literate status				1460.477	< 0.001
literate	5239	4726	513		
illiterate	14528	14528	0		
Mother's occupation				1440.575	< 0.001
Non-agricultural	5292	4779	513		
Farming	14475	14475	0		
Father's occupation				1078.675	< 0.001
Non-agricultural	6485	5972	513		
Farming	13282	13282	0		
CHH					
Self-rated childhood health status				389.924	< 0.001
Much healthier	2903	2903	0		
Somewhat healthier	3240	3240	0		
About average	11358	10845	513		
Somewhat less healthy	1373	1373	0		
Much less healthy	893	893	0		

CSES: childhood socioeconomic status; ASES: adulthood socioeconomic status; CHH: childhood health history; HRB: health-related behaviors; T2DM: type 2 diabetes mellitus; CFI, comparative fit index; AGFI, Adjusted Goodness-of-Fit Index; GFI, Goodness-of-Fit Index; RMSEA, root mean square error of approximation ; SRMR, Standardized Root Mean Square Residual; AIC, Akaike information criterion.

Variables	Overall	T2DM		χ^2	P value
		No	Yes		
Confined to bed because of health				27.621	< 0.001
No	18782	18269	513		
Yes	985	985	0		
Hospitalized in for a month or more				9.963	0.002
No	19400	18887	513		
Yes	367	367	0		
Hospitalized more than three times				4.949	0.026
No	19583	19070	513		
Yes	184	184	0		
Sex				0.634	0.426
Male	9552	9313	239		
Female	10215	9941	274		
ASES					
Individual’s education attainments				285.546	< 0.001
>12 years	564	489	75		
7–12 years	6717	6514	203		
1–6 years	8550	8388	162		
Illiterate	3936	3863	73		
Residential area				1187.019	< 0.001
Urban	6075	5562	513		
Rural	13692	13692	0		
HRB					
Alcohol drinking status				19.894	< 0.001

CSES: childhood socioeconomic status; ASES: adulthood socioeconomic status; CHH: childhood health history; HRB: health-related behaviors; T2DM: type 2 diabetes mellitus; CFI, comparative fit index; AGFI, Adjusted Goodness-of-Fit Index; GFI, Goodness-of-Fit Index; RMSEA, root mean square error of approximation ; SRMR, Standardized Root Mean Square Residual; AIC, Akaike information criterion.

Variables	Overall	T2DM		χ^2	P value
		No	Yes		
Drink more than once a month	1759	1694	65		
Drink less than once a month	5278	5115	163		
No drinking	12730	12445	285		
Smoking habits				59.022	< 0.001
Past smoker	1464	1464	0		
Current smoker	17775	17262	513		
Non-smoker	528	528	0		
Goodness-of-fit					

CFI	AGFI	GFI	RMSEA	SRMR	AIC
0.803	0.904	0.938	0.082	0.060	9089.595

CSES: childhood socioeconomic status; ASES: adulthood socioeconomic status; CHH: childhood health history; HRB: health-related behaviors; T2DM: type 2 diabetes mellitus; CFI, comparative fit index; AGFI, Adjusted Goodness-of-Fit Index; GFI, Goodness-of-Fit Index; RMSEA, root mean square error of approximation ; SRMR, Standardized Root Mean Square Residual; AIC, Akaike information criterion.

SEM

The hypothesized model based on conceptual framework and previous literature specified in Fig. 1 has 6 major components: CSES variables, CHH variables, ASES variables, HRB variables, T2DM and Sex. Optimal SEMs were developed by inspecting the significance of constructs' theoretical relevance and path coefficients to fit the data and obtain theoretically sense. Figure 2 described the path diagram for the whole sample labelled on each path to aid interpretation of coefficients. Tables 2 and 3 illustrated standardized estimates of direct, indirect and total effects of the SEM model. In model 1, female was directly associated with higher incidence of T2DM (sβ = 0.024, P < 0.05). The CSES was the largest predictor of incidence of T2DM (sβ = -0.239; P = 0.001), indicating that participants who reported lower CSES were more likely to develop T2DM. Significant indirect pathways between CSES and T2DM were observed (sβ = -0.111; P = 0.001). CSES indirectly predicted T2DM via CHH and CSES, specific pathways were as followed: worse CSES → worse CHH → higher risk of T2DM = 0.057 × -0.016 = -0.0009. Another pathway via ASES was followed as: worse CSES → worse ASES → higher risk of T2DM = 0.607 × -0.180 = -0.109. Therefore, CHH and ASES partially mediated the association between CSES and T2DM. Besides, CSES also had indirect associations with HRB significantly via CHH (sβ = -0.030; P = 0.034) and ASES (sβ = 0.176; P = 0.005), respectively. The model presents that AGFI and GFI > 0.90, RMSEA < 0.10, SRMR < 0.08, AIC = 9088.595, indicating an acceptable model fit.

Table 2

Standardized estimated coefficients of SEM

Pathway			S(β)	P-value
CHH	<—	CSES	0.057	< 0.001
HRB	<—	CHH	-0.028	0.032
HRB	<—	CSES	0.088	< 0.001
ASES	<—	CHH	0.012	0.394
ASES	<—	CSES	0.597	< 0.001
ASES	<—	HRB	0.112	0.660
Father's educational attainment	<—	CSES	0.417	< 0.001
Mother's literate status	<—	CSES	0.619	< 0.001
Mother's occupation	<—	CSES	0.746	< 0.001
Father's occupation	<—	CSES	0.750	< 0.001
Self-rated childhood health status	<—	CHH	0.191	< 0.001
Hospitalized more than three times	<—	CHH	0.381	< 0.001
Confined to bed because of health	<—	CHH	0.522	< 0.001
Hospitalized in for a month or more	<—	CHH	0.636	< 0.001
Residential area	<—	ASES	0.711	< 0.001
Individual's educational attainments	<—	ASES	0.373	< 0.001
Alcohol drinking status	<—	HRB	0.726	< 0.001
Smoking habits	<—	HRB	0.025	0.658
T2DM	<—	CHH	-0.016	0.080
T2DM	<—	CSES	-0.239	< 0.001
T2DM	<—	ASES	-0.180	< 0.001
T2DM	<—	HRB	-0.007	0.710
T2DM	<—	SEX	0.024	< 0.001

(CSES: childhood socioeconomic status; ASES: adulthood socioeconomic status; CHH: childhood health history; HRB: health-related behaviors; T2DM: type 2 diabetes mellitus.)

Table 3
Total effects, direct effects and indirect effects of SEM

Predictor	Response	Direct effect	Indirect effect	Total effect
CSES	CHH	0.057***	0.000	0.057***
	ASES	.607***	0.000	0.607***
	HRB	-0.018*	0.105***	0.087***
	T2DM	-0.239***	− .111***	− .349***
CHH	ASES	0.009	0.000	0.009
	HRB	− .030**	0.002	-0.028
	T2DM	− .016***	-0.001	− .017***
ASES	LS	0.176***	0.000	0.176***
	T2DM	-0.180***	0.000	-0.181***
HRB	T2DM	− .007	0.000	-0.007
Sex	T2DM	.024***	.000	0.024***
*** P < 0.01; ** P < 0.05; * P < 0.1.				

Discussion

According to the LCHD conceptual theory, this study was first employing SEMs to decompose the complex effects of CSES on T2DM among mid-late Chinese, and found that CSES was associated with T2DM directly and indirectly, the indirect pathway was mediated by CHH and ASES respectively (35), which indicated that each LCHD approach, including sensitive period model, pathway model and social mobility model may partially account for socioeconomic disparities in the incidence of T2DM and no models fit all the effects, highlighting that it was imperative to improve and obtain optimal well-being of disadvantaged children from early stage to bridge the socioeconomic gap in health and promote health equity across the life course.

After disentangling the effect of CSES on T2DM, the indirect association between CSES via ASES and CHH separately and the strong relation found between CSES and ASES supported the pathway model of LCHD theory, which is in agreement with Vendrame et al (21). Tsenkova et al suggested that CSES might drive the trajectories of socioeconomic inequity that ultimately induce negative health problems despite the absence of direct link from CSES to T2DM, the effect of which at least partially mediated by ASES and other risk factors (36). Confusing results have been yielded by prior studies with regard to the relationship between CSES and T2DM, some studies showed that CSES was independent from ASES with profound effect across the life span (12). For example, Marmot et al reported a weaker effect of CSES

compared to ASES in the associations with health in later life among British civil servants (37), and Hallqvist et al found no interaction effect between CSES and ASES in the Stockholm Heart Epidemiology Program, which suggested that socioeconomic trajectories might not predict the incident of T2DM among the study sample (38). Agardh et al reported that participants with lower parental occupational position were more likely to develop T2DM in later life, this relationship was attenuated after adjusting for ASES (39), which was not able to test pathway model effectively.

Considering socioeconomic inequality is relatively stable over the life course, this study highlighted that indirect relation between CSES and T2DM was mainly mediated by ASES. Previous studies have found individuals with low CSES have a higher risk of low ASES in adulthood (40), this study added to the literature by showing that worse CSES was directly associated with worse ASES. Individuals with lower CSES tend to be surrounded by poorer sanitation, higher burden of disease, less medical service, narrower living space, and even less food availability (41, 42), thereby they have worse physical qualities from childhood and suffer higher levels of inflammation related to T2DM (43, 44). Individuals come from a family with low CSES, obtain limited access to qualified schools, achieve few opportunities to jobs requiring higher education attainments, and therefore they may maintain their low level of SES into adulthood (35), for example, in the American, children with poor CSES were liable to lag behind their peers by one standard deviation, and families with poor SES tended to invest in more immediate family needs than in the development and education of their children (45). Similarly, in the Princeton School District Study, educational attainments of mother was found to be a risk factor for the incidence of T2DM (17).

Evidence have been well established on the strong relationship between ASES and T2DM, and ASES might not completely explain the relationship. CSES was shown to take a leading position over ASES in the relationship with T2DM in the prospective studies (46), while concurrent SES was shown with a stronger effect in the retrospective studies (47), implying that CSES might dominate the association with T2DM. Considering the context of rapidly changing economic and social structures in China over the last 3 decades is of great relevance, compared to their counterparts in western countries, mid-late Chinese have experienced remarkable socioeconomic changes, they experienced poor CSES and obtained much improved living conditions in their later adulthood for the economic reforms in the 1980s and 1990s (22). According to the social mobility model, stable poor socioeconomic trajectory or downward social mobility across the life course are both negatively linked with later health outcomes, thereby such upward social shifts may also adjust the association in this study. Further nationwide longitudinal studies are needed to support the relationship between CSES and adulthood health, especially for large-scale birth cohort study which is fairly limited in China, there is great urge to build broad birth cohort studies.

This study also showed the mediating effects of CHH in the association between CSES and T2DM, which is in line with a latest study indicated that children with higher levels of fitness has a tendency to decrease the likelihood of later health problems (48). Individuals with disadvantaged CSES may have limited access to medical care services, stimulating worse physical fitness pediatric health problems, which have been associated with increased risks of disorders of mental and physical developments such as developmental delay, asthma and sleep disruption (49, 50). Studies have showed that the gradual

translation of increased activation of the stress response into decreased cortisol production, which was impeditive during childhood development (51), from a microscopic perspective, changes in inflammatory factors, immune factors and epigenetic factors also been reported in a recent review highlighting the complexity of the biological response to hardships (49).

Echoing with the hypotheses, the direct effects of both CSES and CHH to T2DM supported the sensitive period model, which was in agreement with Derks et al, who found that disadvantaged CSES was associated with diabetes-related outcomes in the Maastrict study (9). Similarly, lower CSES was found to be associated with increased risks of T2DM among African American adults in the Jackson Heart Study (10). In addition, a population-based longitudinal study conducted in the United States revealed that women with poor CSES was associated with higher prevalence of T2DM compared to men (52), however, this study could not corroborate this relationship for the insignificant pathway. An emerging body of researches suggested that childhood constitute a sensitive and critical period of growth and development that had remarkable implications for the whole life when individuals were susceptive to detrimental exposures (53). CSES hardships usually indicated few parent-child interactions, undermined parental authority and indifferent parent-child relationship (54), which might contribute to elevated stress levels and inflammation processes conducive to the incident of T2DM (43, 55). Various studies showed that individuals brought up with poor CSES may experience worse health outcomes such as metabolic disorders than those who living in more affluent areas, independent of ASES (56, 57), besides, experimental animal models provided robust evidence that adverse early life condition was a risk factor for metabolic disorders development in aging mice (58).

There were no specified explanatory mechanisms were established yet, one possibility refers to the stress-mediated pathway. As a chronic stressor, childhood socioeconomic hardship was linked to elevated hormone levels, catecholamines, and cortisol (59), which could also increase the blood levels of triglycerides, free fatty acids, glucose and insulin and trigger sustained changes in the central nervous system, dysregulating the hypothalamic–pituitary–adrenal (HPA) axis, and thus influenced the pathological development of T2DM (3, 60). Stress could modify lipid metabolism and, subsequently, and insulin sensitivity thereby conducing to the incident of T2DM (61). In addition, inflammation could be a potential intermediator between CSES and T2DM which was confirmed a significant association between CSES and inflammation such as inflammatory cytokines which plays an involvement role in the development of T2DM (44, 62). Furthermore, CSES might be linked to the development of T2DM through malnutrition, which may contribute to glucose and energy metabolic impairment such as elevated sensitivity of peripheral insulin, increased hepatic glucose production, reduced sensitivity of insulin and developmental disorders of pancreatic, which etiologically contributed to paving the way of developing T2DM (63). Another psychosocial pathway might refer to the absence of self-control ability that has been commonly observed in individuals with poorer ASES and CSES (64), which might shape the dietary behaviors of individuals contributing to T2DM in turn.

Findings from this study are generally similar to preceding studies regarding childhood conditions and ASES, but not completely so. CHH was not associated with ASES, contrast with previous research on the

effect of childhood health, which has indicated poor CHC to be related to lower ASES and more negative health outcomes (65). Surprisingly, the nonsignificant pathway between HRB and T2DM was found in the pathway model that was inconsistent with previous literature (36), the inconsistency may due to the absence of dietary behaviors of the participants which was considered as a stronger predictor of T2DM (26), besides, the limited and retrospective childhood conditions and self-reported T2DM status may also account for it.

Strengthens

There were several strengthens of this study. The application of SEMs to explore the relationship between CSES, CHH, ASES, HRB and T2DM compared to the common analysis methods such as logistic regression models could minimize the measurement error and provide stronger results (66). SEM could incorporate multiple variables and untangle the association between CSES and T2DM simultaneously, by building CSES, CHH, ASES and HRB of multiple indices and constructing the network of pathogenesis (66), thus SEM was more appropriate to explore the complicated effects and pathways, which provided robust results through the multiple sequence correlation coefficient matrix (67). Another strengthen of this study includes the data of high quality used in this study, which is a unique nationwide representative survey of mid-late Chinese and designed as representative as feasibly possible for the specific Chinese context (23, 68).

Limitations

In the light of these strengthens, this study also revealed several limitations. First, life course data including CSES and CHH in this study was collected retrospectively, recall bias could be introduced, hence, the findings should be interpreted cautiously. Further longitudinal studies especially for birth-cohort studies should be conducted to explore the exact life-course trajectory and pathways between experiences during or earlier life stage and adulthood health. While this study employed several indices of CSES that cannot examine the specific critical periods and durations, the findings still evidenced the existence of a sensitive period before age of sixteen (35). Second, this study did not incorporate childhood adverse experiences such as child abuse and specify the duration and frequency of disadvantaged CSES, thereby the socioeconomic trajectories of mid-late Chinese was not tested effectively, which have been reported to be associated with negative health outcomes in later adulthood (69). The findings might not be generalized to other countries for the special experiences of mid-late Chinese, although which was similar to some previous literature on the effects of disadvantaged CSES (21). Further longitudinal researches especially natural experiments or intervention studies are needed to understand the life couse mechanisms and narrow the socioeconomic gaps in the incidence of T2DM.

Conclusions

In conclusion, the present study employed SEMs to disentangle the direct and indirect effects of CSES on T2DM, revealing that CSES was a powerful predictor of T2DM with profound effects over the life course via CHH and ASES. These findings found stronger associations between CSES and risk of T2DM than

current ASES, which may imply that childhood is an ideal targeted window for informing interventions to promote health equities among people with different social classes and decrease the risk of T2DM in mid-late adulthood. It is of great significance to incorporate these findings to optimize sound practices and deploy available resources to prevent disadvantages of sensitive period, thereby lower the incidence of T2DM, hence, improving and consummating the legislation, social services and health care system are urgently to be implemented to reduce the prolonged burden of adverse childhood conditions.

Abbreviations

CSES
childhood socioeconomic status; ASES:adulthood socioeconomic status; CHH:childhood health history; HRB:health-related behaviors; T2DM:type 2 diabetes mellitus; CHARLS:Chinese respondents in a Health and Retirement Longitudinal Study.

Declarations

Ethics approval and consent to participate

This study used secondary data from CHARLS. The agency responsible for the survey is Peking University.

Consent for publication

Not applicable.

Availability of data and material

Please contact China Health and Retirement Longitudinal Study (CHARLS) for data requests. http://charls.pku.edu.cn/zh-CN

Competing interests

The authors declared no potential conflict of interest with respect to the authorship and/or publication of this article.

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Authors' contributions

XNZ contributed to the conception and design of the study and critically reviewed the manuscript; XJ contributed to data analysis, drafting and revision of the manuscript; QZ contributed to drafting the manuscript. All authors agreed to be accountable for all aspects of this work.

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Figures

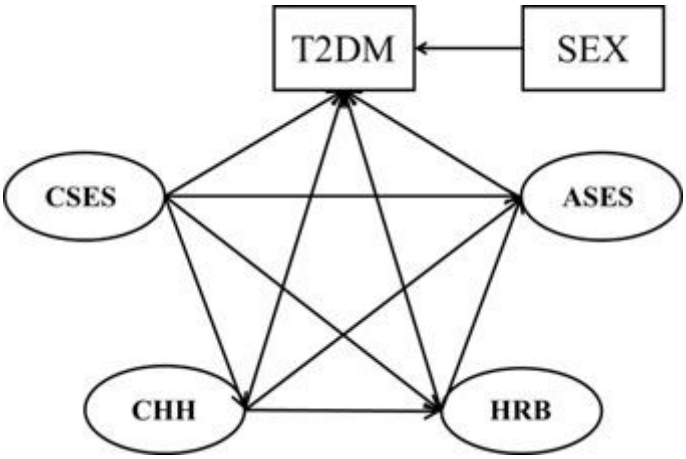

Figure 1

Hypothesized Conceptual model based on the LCHD theory (CSES: childhood socioeconomic status; ASES: adulthood socioeconomic status; CHH: childhood health history; HRB: health-related behaviors; T2DM: type 2 diabetes mellitus; LCHD : life course health development.)

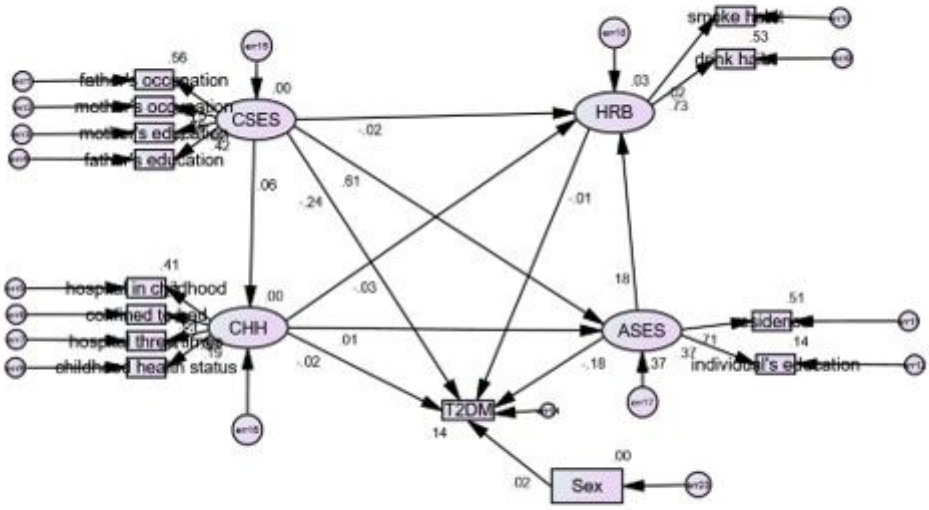

Figure 2

Structural equation model on the pathway between CSES and T2DM (CSES: childhood socioeconomic status; ASES: adulthood socioeconomic status; CHH: childhood health history; HRB: health-related behaviors; T2DM: type 2 diabetes mellitus)

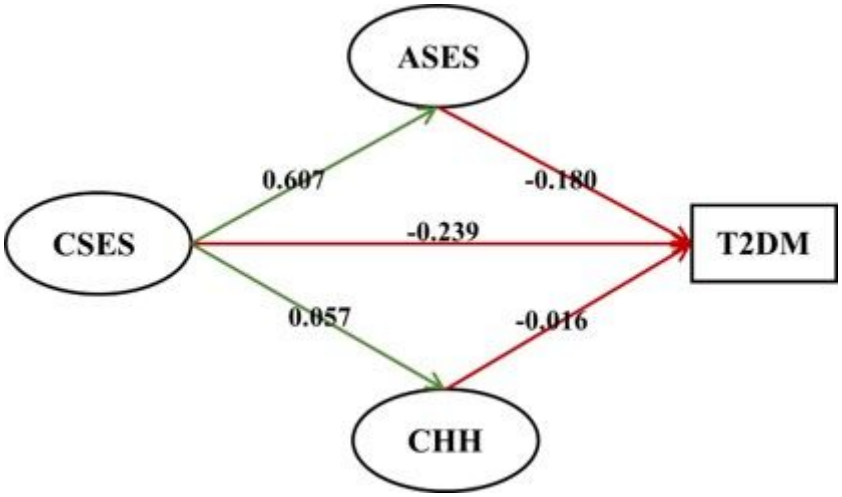

Figure 3

Final pathway between CSES and T2DM (CSES: childhood socioeconomic status; ASES: adulthood socioeconomic status; CHH: childhood health history; T2DM: type 2 diabetes mellitus)