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Risk factors of diabetes in a high risk cardiovascular population in Hainan Province

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This study aimed to understand the influencing factors of diabetes among the cardiovascular high-risk population aged 35–75 in Hainan Province, in order to provide a reference basis for the development of scientific prevention strategies and intervention measures. From January 2016 to February 2023, a random sample of 71,819 residents aged 35–75 in Hainan Province was screened, identifying 12,936 cardiovascular high-risk individuals. All 2,908 diabetic patients were chosen as cases, with a 1:1 age- and gender-matched control group selected from the high-risk pool. Data were organized in Excel and analyzed using SPSS 27.0 for t-tests, chi-square tests, and multi-factorial logistic regression to evaluate lifestyle, dietary habits, blood glucose, and medical history as influencing factors among the high-risk cardiovascular population. BMI (OR = 1.071, 95%CI: 1.053–1.090) and elevated systolic blood pressure (OR = 1.005, 95%CI: 1.002–1.009), a frequency of seafood consumption more than three times per month (OR = 8.098, 95%CI: 7.100-9.237), and an increased ratio of triglycerides to high-density lipoprotein (OR = 1.296, 95%CI: 1.208–1.390) were risk factors for diabetes; whereas high school and below educational level (OR = 0.798, 95%CI: 0.678–0.938), high school above educational level (OR = 0.660, 95%CI: 0.491–0.886), exercise frequency of four or more times per week (OR = 0.621, 95%CI: 0.538–0.716), consumption of fresh vegetables 1–3 times per week (OR = 0.425, 95%CI: 0.283–0.640), and consumption of fresh fruits four or more times per week (OR = 0.743, 95%CI: 0.639–0.865) were protective factors against diabetes. Increased BMI, blood pressure, triglyceride-to-HDL ratio, and frequent seafood consumption were diabetes risks for Hainan's high-risk cardiovascular population. Enhanced screening, follow-up, and promotion of healthy lifestyles, including diet and weight control, were needed to lower disease risks.

Keywords Diabetes, Influencing factors, Case control, Cardiovascular disease

Diabetes is a common endocrine system disorder that can lead to a variety of complications in target organs. The number of diabetes patients and deaths in China is increasing, and the disease burden is continuously rising[1,2]. Diabetes combined with coronary heart disease is a common complication type, and the death risk of patients with both diseases is significantly higher than that of patients with only diabetes[3]. A large number of studies have shown that diabetes and cardiovascular diseases have certain correlations[4]. The cardiovascular high-risk population is a special group that possesses high-risk factors for cardiovascular diseases but has not developed into cardiovascular diseases patient. There are also a large number of diabetes patients in this group. There have been many studies on the risk factors of diabetes in the general population, but this group still deserves attention. In order to reduce the mortality risk caused by the coexistence of cardiovascular diseases and diabetes, it is necessary to study the risk factors in the cardiovascular high-risk population, providing reference for targeted prevention measures of diabetes.

Study subjects and methods

Study subjects

To ensure the feasibility and scientific validity of the project, a variety of factors, including geographical location, economy, and ethnic distribution, are taken into consideration when selecting 8 project sites in Xiuying District of Haikou City, Wenchang City, Ledong County, Danzhou City, Sanya City, Dongfang City, Qionghai City, and Wanning City to conduct cardiovascular risk factor screening. A total of 71,819 individuals are screened as the baseline data, and 12,936 individuals are identified as high-risk individuals. Among the high-risk individuals,

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2,908 patients with diabetes are selected as the case group, and 1:1 matched controls are selected, resulting in a total of 5,816 research subjects.

Inclusion criteria for the screening population
(1) Birth date between January 1, 1947 and December 31, 1987; (2) Reside in the project site for at least 6 months within the past 12 months; (3) Are willing to participate and sign an informed consent form.

Inclusion criteria for high-risk individuals
According to the "2018 Revised Edition of the Chinese Guidelines for the Prevention and Treatment of Hypertension[5]": (1) Disease history (any one of the following): (a) History of myocardial infarction; (b) Received percutaneous coronary intervention; (c) Received coronary artery bypass grafting; (d) History of cerebral infarction (ischemic or hemorrhagic). (2) Any one of the following for blood pressure and lipid levels: (a) SBP ≥ 160 mmHg or DBP ≥ 100 mmHg; (b) LDL-C ≥ 160 mg/dL (4.14 mmol/L). (c) High-density lipoprotein (HDL) < 30 mg/dL (0.78 mmol/L). (3) Cardiovascular disease risk factors According to the 2008 World Health Organization (WHO) Guidelines for Cardiovascular Risk Assessment and Management, all screening subjects are assessed for cardiovascular disease risk using the risk assessment prediction chart. If the screening subject has more than 20% risk of cardiovascular disease in 10 years, they are classified as high-risk individuals. The assessment is based on the following indicators: (a) age; (b) gender; (c) systolic blood pressure (measured twice and the average value taken); (d) current smoking status (all smokers or those who quit smoking within the past year are considered smokers); (e) presence of diabetes (individuals with a previous diagnosis of diabetes, those taking anti-diabetic medication, or those receiving insulin injection); (f) total cholesterol; (g) family history of cardiovascular disease, treatment history, rare genetic disorders, special physical features, or longevity of the screening subject's family members[6]. This project is approved by the Ethics Committee of the Cardiovascular Institute of the Peking Union Medical College and the ethics approval acceptance number is 2014 – 574. (1) identifying the institutional and/or licensing committee approving the experiments, including any relevant details; (2) confirming that all experiments were performed in accordance with relevant guidelines and regulations.

Diagnosis criteria and definitions
Non-diabetic individuals: Fasting blood glucose < 6.1 mmol/L, and 2-hour postprandial blood glucose (2-h PPG) < 7.8 mmol/L after a glucose tolerance test (OGTT); Diabetes (DM): Fasting venous blood glucose ≥ 7.0 mmol/L and/or 2-h PPG ≥ 11.1 mmol/L, or individuals who have previously been diagnosed with diabetes by a township (community) hospital or above.

Research methods
Considering the proportion of permanent urban and rural populations, the city and county of the project are selected according to the 1:2 principle of urban and rural population. The screening objects are strictly determined according to the inclusion and exclusion criteria using the random cluster sampling method. According to the diagnostic criteria, the population with confirmed diabetes is selected, and the cases and controls are determined by the PSM (SPSS - propensity score matching) method according to the principle of age (± 5 years) and gender being the same, with a ratio of 1:1. All personnel involved in the investigation have undergone rigorous training and possess specialized knowledge. The investigation method is consistent, with a unified scheme, unified quality control, unified blood glucose measurement instruments, and measurement methods. In the medical academic setting, the following passage should be translated as follows: Blood pressure (using the Omron HBP-1300 electronic blood pressure monitor from Japan) is measured in a quiet environment, with the subject sitting for 5–10 min before measurement. The average value is taken from three repeated measurements. Blood glucose is measured using a glucometer (Whitejet PD-GOO1-2). Blood glucose detection (electrochemical bio-sensing method): blood is collected from the subject after an 8-hour fast.

Statistical analysis
The data obtained from the survey and related data are sorted using Excel tables, and the sorted data are analyzed using SPSS 27.0 software. Continuous variables are expressed as ± s, and group comparisons are made using t-tests. Categorical variables are expressed as frequencies (%) and compared using chi-square tests. A binary Logistic regression analysis is used to further screen relevant influencing factors. Missing data treatment: Individuals with unknown specific circumstances are defined as missing values (999), and these missing values are not included in the analysis to prevent a reduction in sample size due to the deletion of data with missing values. A two-sided test is used, with an alpha level of 0.05.

Results
Diabetes prevalence among cardiovascular high-risk individuals
In this survey, 12,936 eligible high-risk individuals are identified, including 5,306 men and 7,630 women. The average age of men is (59.36 ± 8.928) years, and the average age of women is (59.66 ± 8.383) years. The age range spans from 35 to 75 years. The male prevalence rate is 24.14% (1,281/5,306), and the female prevalence rate is 21.32% (1,627/7,630), with men showing a higher prevalence than women. The overall prevalence of diabetes among the 12,936 high-risk individuals is 22.46% (2,908/12,936).

Factor	Diabetes group	Non-diabetic group	χ^2Or t value	*P* price
Age (year)	59.61 ± 8.68	59.45 ± 8.68	-0.699	0.485
BMI (cm/kg^2)	24.82 ± 3.65	23.85 ± 3.85	-9.893	< 0.001
sex (n,%)			0.37	0.544
man	1281(44.1)	1304(44.8)		
woman	1627(55.9)	1604(55.2)		
Family annual income(first,%)			7.23	0.065
Less than 100,000	2516(86.5)	2583(88.8)		
100,000–600,000	56(1.9)	45(1.5)		
Greater than 6,000,000	4(0.1)	4(0.1)		
not quite clear	332(11.4)	276(9.5)		
Educational level (n,%)			9.28	0.026
Junior high school and below	2245(77.2)	2154(74.1)		
High school and below	532(18.3)	596(20.5)		
High school above	117(4.0)	147(5.1)		
not quite clear	14(0.5)	11(0.4)		

Table 1. Comparison of general condition indicators in diabetic group and non-diabetic group of cardiovascular high-risk population in Hainan Province($n = 5916$). *In the second and third columns, metric data are presented as the mean ± standard deviation, and count data are expressed as the number of cases (proportion).

Factor	Diabetes group	Non-diabetic group	χ^2Or t value	*P* price
Systolic blood pressure (mmHg)	149.72 ± 23.60	145.04 ± 25.06	−7.323	< 0.001
Diastolic blood pressure (mmHg)	85.85 ± 12.87	84.60 ± 13.63	−3.608	0.002
Total cholesterol (mmol/L)	5.44 ± 1.59	5.70 ± 1.50	-6.348	< 0.001
Low-density lipoprotein (mmol/L)	3.44 ± 1.31	3.58 ± 1.33	-3.785	< 0.001
High-density lipoprotein (mmol/L)	1.39 ± 0.46	1.33 ± 0.45	4.958	< 0.001
Triglyceride (mmol/L)	1.49 ± 1.10	1.85 ± 0.87	-13.823	< 0.001
Triglycerides / HDL	1.68 ± 1.51	1.28 ± 1.13	-11.3799	< 0.001

Table 2. Comparison of BP related indicators in diabetic group and non-diabetic group in cardiovascular high-risk population in Hainan Province($n = 5916$). *In the second and third columns, metric data are presented as the mean ± standard deviation.

Comparison of general characteristics between the diabetes group and non-diabetes group in the high-risk cardiovascular population of Hainan Province

There is no significant difference in age and sex between the case group and the control group ($P > 0.05$), indicating a good matching degree. After accounting for the influence of gender and age on the survey factors of the research population, statistical analysis shows that there is a significant difference in BMI and educational level between the case group and the non-case group ($P < 0.05$), while there is no significant difference in household annual income ($P > 0.05$). See Table 1.

Comparison of blood pressure and lipid-related indicators between the diabetes group and non-diabetes group in the high-risk cardiovascular population of Hainan Province

Statistical analysis of blood pressure-related indicators in the diabetes group and non-diabetes group showed that the proportion of hypertension in the case group was 71.4% (2075/2908) and the proportion in the control group was 60.4% (1756/2908). The difference was statistically significant ($\chi 2 = 77.83$, $P < 0.001$). There were significant differences in systolic blood pressure, diastolic blood pressure, total cholesterol, low-density lipoprotein, high-density lipoprotein, triglycerides, and the triglycerides/high-density lipoprotein ratio between the case group and the control group ($P < 0.001$). See Table 2.

Comparison of diet and lifestyle indicators between the diabetes group and non-diabetes group in the high-risk cardiovascular population of Hainan Province

The statistical analysis of dietary and lifestyle indicators between the diabetes group and the non-diabetes group revealed significant differences in exercise frequency ($\chi 2 = 28.27$, $P < 0.001$), seafood consumption ($\chi 2 = 1210.93$, $P < 0.001$), fresh vegetable consumption ($\chi 2 = 160.11$, $P < 0.001$), and fresh fruit consumption ($\chi 2 = 125.08$, $P < 0.001$) between the case group and the control group. There was no significant difference in the frequency of smoking and drinking ($P > 0.05$). See Table 3.

Factor	Diabetes group	Non-diabetic group	χ^2Or t value	*P* price
How many cigarettes were smoked per day (one)	3.27 ± 9.35	3.71 ± 9.46	1.806	0.071
Exercise frequency (times,%)			28.27	< 0.001
3 times a month or less	1915(65.9)	1850(63.6)		
1–2 times a week	131(4.5)	101(3.5)		
3 times per week	832(28.6)	878(30.2)		
not quite clear	30(1.0)	79(2.7)		
Frequency of drinking (times,%)			2.02	0.569
Less than once a month	2423(83.3)	2448(84.2)		
2–4 times a month	141(4.8)	149(5.1)		
More than 2 times a week	330(11.3)	298(10.2)		
not quite clear	14(0.5)	13(0.4)		
Frequency of the seafood consumption (times,%)			1210.93	< 0.001
3 times a month or less	693(23.8)	2009(69.1)		
More than 3 times a month	2215(76.2)	899(30.9)		
Frequency of eating fresh vegetables (times,%)			160.11	< 0.001
3 times a month or less	120(4.1)	221(7.6)		
1–3 times a week	100(3.4)	152(5.2)		
4 or more times per week	2683(92.3)	2524(86.8)		
not quite clear	5(0.2)	11(0.4)		
Frequency of consuming fresh fruit consumption (times,%)			125.08	< 0.001
3 times a month or less	877(30.2)	820(28.2)		
1–3 times a week	733(25.2)	709(24.4)		
4 or more times per week	1292(44.4)	1364(46.9)		
not quite clear	6(0.2)	15(0.5)		

Table 3. Comparison of dietary and lifestyle indicators of diabetic and non-diabetic groups of cardiovascular high-risk groups in Hainan Province($n = 5916$). *In the second and third columns, metric data are presented as the mean ± standard deviation, and count data are expressed as the number of cases (proportion).

Multivariate logistic regression analysis of diabetes-related risk factors in high-risk cardiovascular population in Hainan Province

After univariate analysis, statistically significant factors were selected, and the independent variables were determined based on the research results. Diabetes was defined as the dependent variable (normal = 0; diabetes = 1), and the independent variables included BMI, systolic blood pressure, diastolic blood pressure, educational level, exercise frequency, frequency of seafood consumption, frequency of fresh fruit consumption, frequency of fresh vegetable consumption, total cholesterol, and the ratio of triglycerides to high-density lipoprotein. Multivariate Logistic regression analysis shows that elevated BMI, systolic blood pressure, and the ratio of triglycerides to high-density lipoprotein, as well as a frequency of seafood consumption exceeding three times per month, are associated with an increased risk of developing diabetes. Higher educational levels, exercise frequency of at least 4 times per week, consumption of fresh vegeTables 1, 2 and 3 times per week, and consumption of fresh fruit more than 3 times per week are protective factors for diabetes. The OR values for increased BMI were 1.060 (1.042–1.079); for systolic blood pressure were 1.005 (1.002–1.009); for consumption of seafood more than 3 times per month were 8.098 (7.100-9.237); for an elevated ratio of triglycerides to high-density lipoprotein were 1.296 (1.208–1.390); for educational level of high school and below were 0.798 (0.678–0.938); for educational level above high school were 0.660 (0.491–0.886); for exercise frequency of at least 4 times per week were 0.621 (0.538–0.716); for consumption of fresh vegeTables 1, 2 and 3 times per week were 0.425 (0.283–0.640); and for consumption of fresh fruit at least 4 times per week were 0.743 (0.639–0.865). See Table 4.

Discussion

In recent years, with rapid urbanization, an aging population, and shifts in lifestyle and dietary habits, the incidence and prevalence of diabetes have increased dramatically[7]. In 2013, the prevalence of diabetes among adults aged 18 and over in China was 10.4%, while for the same age group in Hainan Province, it was 12.0% (standardized rate of 6.5%), higher than the levels in Shanghai and Hubei during the same period[8–10]. In 2014, the prevalence of diabetes in Hainan Province rose to 12.0% (weighted at 9.8%, with a standardized rate of 6.5%), which was significantly higher than the national average and exceeded the current national average[10]. Exploring the influencing factors of diabetes in the Hainan population and implementing targeted prevention measures is crucial for the prevention and control of diabetes. High blood sugar levels are a major risk factor for cardiovascular diseases in diabetic patients, and the coexistence of cardiovascular disease with diabetes increases the risk of coronary heart disease and myocardial infarction[11]. Therefore, health education and behavioral interventions for high-risk cardiovascular populations should not only address the control of cardiovascular disease risk factors but also aim to prevent and control diabetes risk factors.

Variable	Anchoring group	β	S.E	Wald χ^2	*P*	OR	95%CI
BMI (cm/kg^2)		0.069	0.009	59.209	<0.001	1.071	1.053–1.090
cholesterol total (mmol/L)		-0.019	0.059	0.461	0.497	0.981	0.928–1.037
Systolic blood pressure (mmHg)		0.005	0.002	9.096	0.003	1.005	1.002–1.009
Diastolic blood pressure (mmHg)		-0.003	0.003	1.113	0.291	0.997	0.990–1.003
triglyceride/high-density lipoprotein ratio		0.259	0.032	52.050	< 0.001	1.296	1.208–1.390
low-density lipoprotein (mmol/L)		-0.109	0.105	1.075	0.300	0.897	0.730–1.102
Educational level (n)							
High school and below	Junior high school and below	-0.226	0.150	7.483	0.006	0.798	0.678–0.938
High school above		-0.416	0.347	7.639	0.006	0.660	0.491–0.886
Exercise frequency (times)							
1–3 times a week	3 times a month or less	-0.098	0.165	0.355	0.552	0.906	0.655–1.253
4 or more times per week		-0.477	0.073	43.028	<0.001	0.621	0.538–0.716
Frequency of the seafood consumption (times)							
More than 3 times a month	3 times a month or less	2.092	0.067	971.451	<0.001	8.098	7.100–9.237
Frequency of eating fresh vegetables (times)							
1–3 times a week	3 times a month or less	-0.855	0.209	16.791	<0.001	0.425	0.283–0.640
4 or more times per week		-0.015	0.139	0.011	0.915	0.985	0.751–1.293
Frequency of consuming fresh fruit consumption (times)							
1–3 times a week	3 times a month or less	-0.170	0.087	3.782	0.052	0.844	0.711–1.001
4 or more times per week		-0.297	0.077	14.788	<0.001	0.743	0.639–0.865

Table 4. Binary logistic regression analysis of the factors affecting diabetes in the cardiovascular high-risk population in Hainan Province.

In this study, the criterion for non-diabetic individuals was set at FPG < 6.1 mmol/L, which overlaps with the ADA's criterion for prediabetes, defined as FPG 5.6–6.9 mmol/L. In the study by Alpesh Goyal et al.[12], which used combined critical values of FPG 6.1 mmol/L or HbA1c ≥ 6.0% (42 mmol/mol) in an OGTT substitution study, 80.9% of the study cohort were spared from OGTT without missing any diabetes diagnoses. Similarly, Mary R. Rooney et al.[13] also used FPG 6.1 mmol/L as the threshold for prediabetes. Therefore, there is theoretical support for selecting this criterion as the threshold for non-diabetic individuals. Moreover, this study also included glucose tolerance testing(2 h post-glucose < 7.8 mmol/L in OGTT-2 h) to determine non-diabetic individuals. Even with the overlap with prediabetes, the corresponding indicators and symptoms are relatively mild. In this study, the 5,816 study subjects had high-risk factors for cardiovascular disease but did not develop cardiovascular disease. The prevalence of diabetes among this population was 22.46%, higher than the 12.0% prevalence of diabetes in Hainan Province in 2014[10], suggesting that the prevalence of diabetes among high-risk cardiovascular populations was higher than that of the general population. Through a 1:1 matched case-control study among diabetic patients and non-diabetic individuals in this population, significant differences were found in the prevalence of diabetes among different groups of individuals with varying BMIs, educational levels, exercise frequencies, frequencies of seafood, fresh vegetables, and fresh fruits consumption, blood pressure levels, total cholesterol, low-density lipoprotein, high-density lipoprotein, triglycerides, and triglycerides/high-density lipoprotein ratios ($P < 0.05$). Studies suggest that smoking is a risk factor for cardiovascular disease[5] and is also closely related to the development of diabetes[14]; however, in this study, the average daily smoking rate in the diabetes group was lower than that of the non-diabetes group. Since this study was cross-sectional, we cannot determine the causal relationship between lifestyle and disease, and there may be survivor bias or the group may have received more health education and adopted smoking cessation behaviors.

It has been demonstrated that the triglyceride/high-density lipoprotein ratio in the serum of patients with prediabetes and diabetes is elevated compared to those with normal blood glucose levels[15]. This ratio, also known as the atherosclerosis index, is one of the most significant risk factors for cardiovascular diseases. It has been verified as an independent predictor and can be used to predict insulin resistance, cardiovascular diseases, the prognosis of prediabetes, the incidence of coronary artery disease, cardiovascular mortality, and the onset of diabetes in patients with type 2 diabetes[16–19]. The research findings of this experiment indicate a statistically significant difference in the value of this ratio between the diabetic and non-diabetic populations. Logistic regression analysis shows a correlation with an increased risk of diabetes, which is consistent with the results of this study. Furthermore, the TG/HDL-C ratio is a reproducible and readily calculable predictor of atherosclerosis in routine clinical practice[20]. Incorporating the triglyceride/high-density lipoprotein ratio in the early screening of diabetes in cardiovascular high-risk populations has practical value for the risk prediction of diabetes.

In this study, the risk of developing diabetes was significantly higher in individuals who consumed seafood more than 3 times per month compared to those who consumed it less than or equal to 3 times per month. Numerous studies on the prevention of diabetes and the Mediterranean diet suggest that increased seafood intake is crucial for preventing diabetes[21], which contradicts the findings of this study. Sahay R D[22] conducted a cross-sectional study on 1,379 adults aged 20–94 on the island of Kherva and found that the highest quartile

of fish intake was associated with an increased risk of diabetes compared to the lowest quartile, suggesting that higher fish intake may be linked to an increased risk of diabetes. Villegas R[23] conducted a prospective cohort study on 64,193 women and 51,963 men in Shanghai and found that in women, the four groups with higher fish intake had a negative association with diabetes risk compared to the lowest quintile of fish intake, while in men, fish intake was not associated with diabetes risk. Wallin A[24] conducted a study on 3,558 men aged 45–79 in Sweden and found no association between fish intake and diabetes. Collectively, existing studies indicate a degree of controversy regarding the relationship between fish intake and diabetes, and this relationship may vary by gender[25]. Therefore, whether increasing fish intake positively affects the prevention of diabetes requires further investigation. In Hainan, locals prefer to boil seafood and dip it in soy sauce, various condiments, and other sauces. As seafood consumption increases, so might the use of these condiments. This study only investigated seafood intake but did not conduct a detailed classification or survey of the preferences and quantities of seasonings used by the study population when consuming seafood. The amount of sugar and salt in the dipping sauce consumed by the study population when eating seafood was not fully estimated, which may introduce bias in the study. Unhealthy dietary habits are significant risk factors for cardiovascular diseases and diabetes[26,27], making dietary intervention an important means of preventing these diseases. It is recommended that follow-up surveys of cardiovascular high-risk populations in Hainan Province include survey projects with Hainan-specific features to enhance the precision of the survey. Additionally, the study subjects were cardiovascular high-risk individuals, and their glucose and lipid metabolism may differ from that of the general population to some extent. Further mechanism-based exploratory studies are needed. The impact factors such as heavy metals, microplastics, and antibiotics in different types of seafood may also differ from other regions, necessitating further research.

Conclusion

In conclusion, factors such as BMI, exercise frequency, seafood consumption frequency, fresh fruit consumption frequency, systolic blood pressure, HDL, and triglycerides impact the development of diabetes among the cardiovascular high-risk population in Hainan Province, and attention should be paid to the prevention and control of these related factors. Although there are studies domestically and internationally that suggest increasing fish intake can reduce the risk of diabetes, this study found that increasing seafood intake among the cardiovascular high-risk population in Hainan Province would increase the risk of diabetes; thus, the impact of seafood on diabetes in Hainan Province warrants further research.

Data availability

1.The data that support the findings of this study are available from CDC of Hainan province but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the corresponding authors upon reasonable request and with permission of CDC of Hainan province.2.The data employed in this experiment originated from the "Major Public Health Service Project of the National Health Commission: Early Screening and Comprehensive Intervention Project for High-Risk Population of Cardiovascular Diseases". The project number before 2019 was Z135080000022, and after 2019, it was Z195110010004.Other than the data collection of the national project, no additional funds were generated in this experiment.

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Author contributions

Liying Zhao was fully involved in the design and writing of the thesis, while Mingsi Chen helped resolve some doubts and revised the experimental design section.Ying Lu carried out quality control throughout the thesis writing process and made the final revisions.Zhou Xue provided data and English polishing for the thesis.

Declarations

Competing interests

The authors declare no competing interests.

Ethical approval

This experiment has been approved by the ethics committee of the off-site hospital, and the approval documents are presented in Appendix 1. This study is of the type of data analysis rather than a clinical trial.

Informed consent

This study was informed consent was obtained from all participants and/or their legal guardians.

Additional information

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