ISSN 1949-8462 (online)

World Journal of *Cardiology*

World J Cardiol 2024 December 26; 16(12): 673-786

Published by Baishideng Publishing Group Inc

World Journal of Cardiology

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NAME OF JOURNAL
World Journal of Cardiology

ISSN
ISSN 1949-8462 (online)

LAUNCH DATE
December 31, 2009

FREQUENCY
Monthly

EDITORS-IN-CHIEF
Ramdas G Pai, Dimitrios Tousoulis, Marco Matteo Ciccone, Pal Pacher

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https://www.wjgnet.com/1949-8462/editorialboard.htm

PUBLICATION DATE
December 26, 2024

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https://www.wjgnet.com/bpg/gerinfo/242

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https://www.wjgnet.com/bpg/GerInfo/239

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World Journal of Cardiology

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World J Cardiol 2024 December 26; 16(12): 731-739

DOI: 10.4330/wjc.v16.i12.731

ISSN 1949-8462 (online)

ORIGINAL ARTICLE

Retrospective Study

Trends in cardiovascular and cerebrovascular health scores in the Kailuan population from 2006 to 2011

Yao Yu, Zhao-Xu Zhang, Su-Feng Yin, Shou-Ling Wu, Zun-Jing Liu

Specialty type: Cardiac and cardiovascular systems

Provenance and peer review: Unsolicited article; Externally peer reviewed.

Peer-review model: Single blind

Peer-review report's classification

Scientific Quality: Grade C
Novelty: Grade C
Creativity or Innovation: Grade B
Scientific Significance: Grade B

P-Reviewer: Liu WC

Received: May 17, 2024
Revised: October 30, 2024
Accepted: November 5, 2024
Published online: December 26, 2024
Processing time: 193 Days and 5.1 Hours

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Abstract

BACKGROUND

The American Heart Association defines cardiovascular health in terms of four behaviors (smoking, diet, physical activity, and body weight) and three factors (plasma glucose, cholesterol, and blood pressure). By this definition, the prevalence of ideal cardiovascular health behaviors and factors (ICHBF) is negatively correlated with all-cause mortality and risks of cardiovascular and cerebrovascular diseases and malignancy.

AIM

To investigate the changing trends of cardiovascular and cerebrovascular health scores in the Kailuan study population from 2006 to 2011.

METHODS

The Kailuan population data from three health checkups held in 2006-2007, 2008-2009, and 2010-2011 were analyzed, and the constituent ratios of cardiovascular and cerebrovascular health behaviors and factors at ideal, intermediate, and poor levels were calculated by using Huffman and Capewell method. Simultaneously, the cardiovascular and cerebrovascular health behavior and factor scores were calculated.

RESULTS

From 2006 to 2007, the proportion of people with ideal physical exercise, low salt

diet, ideal body mass index, ideal total cholesterol level, no smoking, ideal blood sugar, and ideal blood pressure was 13.12%, 9.34%, 49.17%, 64.20%, 49.27%, 69.99%, and 20.55%, respectively, in men with a health score of 8.46, and 12.00%, 9.13%, 61.60%, 64.28%, 98.19%, 78.90% and 36.92% in women, with a score of 10.02. From 2008 to 2009, the proportion was 16.09%, 14.04%, 51.94%, 65.02%, 40.18%, 66.44%, and 17.04% in men, with a score of 8.18, and 16.860%, 17.360%, 64.010%, 67.433%, 98.220%, 76.370%, and 42.340% in women, with a score of 10.12. From 2010 to 2011, the proportion was 12.22%, 17.65%, 49.40%, 68.33%, 48.17%, 64.67%, and 14.68% in males, having a score of 8.21, while in females, the proportion was 11.83%, 18.09%, 49.40%, 67.85%, 98.82%, 74.52%, and 37.78%, with a score of 9.90.

CONCLUSION

The prevalence of ideal cardiovascular and cerebrovascular health behaviors and factors is low in the Kailuan study population due to inadequate scores of relevant health metrics.

Key Words: Cardiovascular diseases; Cerebrovascular diseases; Health behaviors and factors; Kailuan study; Retrospective study

Core Tip: The American Heart Association defines ideal cardiovascular health as the concurrent presence of ideal health parameters (blood glucose, total cholesterol, and blood pressure levels) and ideal health behaviors (weight status, diet, physical activity, and smoking). Our study design was retrospective and based on the Kailuan study. This prospective study was initiated in July 2006 to evaluate the risk factors and interventions for cardiovascular diseases and cerebrovascular diseases in the Kailuan community population, with several articles having been published on such chronic non-communicable diseases. A fixed population was constituted from these 57659 participants, and their cerebrovascular and cardiovascular health parameters and behaviors were surveyed from 2006 to 2011. Furthermore, the distributions of cardiovascular health parameters and behaviors were portrayed, and their health scores were estimated.

Citation: Yu Y, Zhang ZX, Yin SF, Wu SL, Liu ZJ. Trends in cardiovascular and cerebrovascular health scores in the Kailuan population from 2006 to 2011. *World J Cardiol* 2024; 16(12): 731-739
URL: https://www.wjgnet.com/1949-8462/full/v16/i12/731.htm
DOI: https://dx.doi.org/10.4330/wjc.v16.i12.731

INTRODUCTION

The American Heart Association (AHA) defines ideal cardiovascular health as the concurrent presence of ideal health parameters (blood glucose, total cholesterol, and blood pressure levels) and ideal health behaviors (weight status, diet, physical activity, and smoking)[1]. Cerebrovascular and cardiovascular conditions are the leading cause of death worldwide and remain one of the foremost health challenges faced by the global population. Moreover, the prevalence of ideal cardiovascular health parameters and behaviors is negatively correlated with all-cause morality along with the innate risk of cardiovascular conditions and malignancies. Several identical risk factors have now been identified for increased risks of cerebrovascular and cardiovascular conditions across varying populations, although the incidence and disease burden vary by region. However, there has been a decline in the occurrence of cerebrovascular and cardiovascular diseases (CVD) owing to major lifestyle improvements[2].

Ideal cardiovascular health metrics are also protective against cerebrovascular diseases[3,4]. Continuous improvement of ideal cardiovascular and cerebrovascular health behaviors and factors exhibits positive significance for the prevention of CVD and cerebrovascular diseases.

Our study design was retrospective and based on the Kailuan study. This prospective study was initiated in July 2006 to evaluate the risk factors and interventions for CVD and cerebrovascular diseases in the Kailuan community population, with several articles having been published on such chronic non-communicable diseases[5-7]. The Ethics Committee of Kailuan General Hospital approved this study.

Kailuan community is a functional community owned and managed by Kailuan group, which pays for the health examinations of all in-service and retired employees every two years[8]. A total of 11 medical institutions are responsible for the healthcare services of the whole community.

Three health examinations were organized successively in 2006-2007, 2008-2009, and 2010-2011 which were attended by 57659 employees, while others undertook one or two health examinations. A fixed population was constituted from these 57659 participants, and their cerebrovascular and cardiovascular health parameters and behaviors were surveyed from 2006 to 2011. Furthermore, the distributions of cardiovascular health parameters and behaviors were portrayed, and their health scores were estimated.

MATERIALS AND METHODS

Subjects

A total of 57659 people participated in all three health examinations (2006-2007, 2008-2009, and 2010-2011) and were included as subjects; their cardiovascular and cerebrovascular health behaviors and factors were evaluated from 2006 to 2011. The inclusion criteria were: (1) Age ≥ 18 years; (2) Cognitive ability sufficient to fill in the questionnaire by themselves; and (3) Signed an informed consent form. Subjects with missing data on cardiovascular and cerebrovascular health behaviors and factors were excluded.

Definition of cardiovascular and cerebrovascular health metrics behaviors and factors

The determination of cardiovascular and cerebrovascular metrics in our study was based on the seven criteria proposed by the AHA[1]. According to the definition of the AHA, smoking, leisure-time physical activity, and diet are defined as cerebrovascular health behaviors, and body weight, fasting plasma glucose, total cholesterol, and blood pressure are defined as cerebrovascular health factors. Never-smoker or quitting smoking ≥ 12 mo ago, diet score = 4/5, ≥ 150 min/wk moderate intensity or ≥ 75 min/wk vigorous intensity or ≥ 150 min/week moderate and vigorous physical activity, body mass index (BMI) < 25 kg/m^2, fasting plasma glucose < 100 mg/dL, total cholesterol < 200 mg/dL, and systolic blood pressure (SBP) < 120 mmHg or diastolic blood pressure (DBP) < 80 mmHg are defined as ideal health behaviors and factors. Intermediate health behaviors and factors are quitting smoking < 12 mo ago, diet score = 2/3, 1-149 min/wk moderate intensity or 1-74 min/wk vigorous intensity or 1-149 min/wk moderate and vigorous physical activity, BMI 25.0-29.9 kg/m^2, fasting plasma glucose 100-125 mg/dL or treated to goal, total cholesterol 200-239 or treated to goal, and SBP 120-139 mmHg or DBP 80-89 mmHg or treated to goal. Poor health behaviors and factors include current smoker, diet score = 0/1, no physical activity, BMI ≥ 30 kg/m^2, fasting plasma glucose ≥ 126 mg/dL, total cholesterol ≥ 240 mg/dL, and SBP ≥ 140 mmHg or DBP ≥ 90 mmHg. Diet score (scale: 0-5) is calculated based on 1 point for each of the following five components: ≥ 4.5 cups per day fruits/vegetables; ≥ two 3.5 oz servings of fish per week; < 1500 mg/d sodium; ≤ 450 kcal (36 oz) per week sweets/sugar-sweetened beverages; and ≥ three servings per day whole grains (1.1 g of fiber in 10.0 g of carbohydrate; 1.0 oz equivalent servings).

There was no vegetable intake in the Kailuan study questionnaire, and the 2002 National Nutrition and Health Survey of China showed that only 18.4% of Chinese people consumed < 6 g of salt daily. Considering the impact of salt intake in the Chinese population, we used the salt preference index to replace the dietary structure index proposed by the AHA. Since the specific daily salt intake could not be accurately measured, we divided the salt preference into high, medium, and low levels, with low level replacing the ideal level of AHA metrics. The questionnaire provided an approximation of whether an individual's salt preference was "ideal", "intermediate", or "poor" as described previously[8].

Our seven cardiovascular and cerebrovascular health behaviors and factors are as follows: Never-smoker, low salt preference, very active (≥ three times/wk and ≥ 30 min each time) physical activity, BMI < 25 kg/m^2, fasting plasma glucose < 100 mg/dL, total cholesterol < 200 mg/dL, and SBP < 120 mmHg or DBP < 80 mmHg were defined as ideal health behaviors and factors. Intermediate health behaviors and factors were former smoker but not now, medium salt preference, moderately active physical activity, BMI 25.0-29.9 kg/m^2, fasting plasma glucose 100-125 mg/dL or treated to goal, Total cholesterol 200-239 or treated to goal, and SBP 120-139 mmHg or DBP 80-89 mmHg or treated to goal. Poor health behaviors and factors included current smoker, high salt preference, inactive (none), BMI ≥ 30 kg/m^2, fasting plasma glucose ≥ 126 mg/dL, total cholesterol ≥ 240 mg/dL, and SBP ≥ 140 mmHg or DBP ≥ 90 mmHg.

Definition of cardiovascular and cerebrovascular health scores

To capture individual-level changes, we used the Huffman and Capewell method[1], which provides a cardiovascular score based on an aggregate of all seven cardiovascular health metrics (poor = 0 points; intermediate = 1 point; ideal = 2 points; scale: 0-14 points for all metrics). This score was not a risk prediction tool but contributed to assessing individual-level trends amid population-level trends.

Survey questionnaire and anthropometric determination

Specific procedures can be found in prior studies[9-11].

Statistical analysis

SPSS 19.0 software (IBM, Chicago, IL, United States) was used for statistical analyses. Behavioral, sociodemographic, and clinical parameters were described that influenced gender differences. Continuous data are expressed as the mean ± SD.

RESULTS

Out of 57659 people participating in the three physical examinations held from 2006 to 2011, 12461 people had incomplete data on health and behavioral factors; hence 45198 subjects were finally included in the statistical analysis, including 34720 (77.82%) men and 10478 women, respectively. In 2006, the average age was (47.9 ± 11.6) years. Additionally, the proportion of people with ideal physical exercise, low salt diet, ideal body mass index, ideal total cholesterol level, no smoking, ideal blood sugar, and ideal blood pressure was 13.12%, 9.34%, 49.17%, 64.20%, 49.27%, 69.99%, and 20.55% for men, and 12.00%, 9.13%, 61.60%, 64.28%, 98.19%, 78.90%, and 36.92% for women from 2006 to 2007. The 2008-2009 data revealed that the proportion of men with ideal physical exercise, low salt diet, ideal body mass index, ideal total

cholesterol level, no smoking, ideal blood sugar, and ideal blood pressure was 16.09%, 14.04%, 51.94%, 65.02%, 40.18%, 66.44%, and 17.04%, and it was 16.86%, 17.36%, 64.01%, 67.433%, 98.22%, 76.37%, and 42.34% for women. From 2010-2011, the proportion of men with ideal physical exercise, low salt diet, ideal body mass index, and ideal total cholesterol level, no smoking, ideal blood sugar, and ideal blood pressure was 12.22%, 17.65%, 49.40%, 68.33%, 48.17%, 64.67%, and 14.68%, and it was 11.83%, 18.09%, 49.40%, 67.85%, 98.82%, 74.52%, and 37.78% in women. The prevalence of ideal cardiovascular and cerebrovascular health behaviors and factors of different genders from 2006 to 2011 is shown in Table 1 and Table 2. The prevalence of poor and intermediate cardiovascular and cerebrovascular health behaviors and factors of different genders from 2006 to 2011 was described in our previous research[11].

The health scores of men and women in 2006, 2008, and 2010 were 8.46 and 10.02, 8.18 and 10.12, as well as 8.21 and 9.90, respectively; the distribution of cardiovascular and cerebrovascular health behaviors and factor scores of different genders from 2006 to 2011 are shown in Table 3 and Table 4.

The mean ± SD of body mass index, blood pressure, fasting blood glucose, and total cholesterol levels of different genders from 2006 to 2011 are shown in Table 5 and Table 6.

DISCUSSION

Our results revealed that the distribution of cardiovascular and cerebrovascular health behaviors and factors in this study population was low from 2006 to 2011; since the ideal level of population composition was not high, the resultant score was low. Therefore, effective health education programs are needed to improve individual and group health behaviors. Furthermore, the definition of eating habits and physical exercise that we proposed was different from that suggested by the AHA; however, if AHA-defined outlines were implemented, the health behavior and factors and scores of this population might have been worse.

To interpret these results, it is necessary to understand the association between the characteristics of the study population as well as the cardio- and cerebrovascular health in China. China has the largest smoking population[12], with around 300 million adult smokers, which constitute nearly one-third of global smokers, and the economic burden caused by smoking is about 350 million dollars every year[13]. In our study, the number of smokers was half of the entire study population, suggesting that smoking was an important risk factor for CVD and cerebrovascular diseases[14,15]. Henceforth, quitting smoking might reduce the incidence of CVD and cerebrovascular diseases in China[16,17]. The Healthy China 2030 initiative intends to reduce the prevalence of smoking from 27.7% in 2015 to 20.0% by 2030. Hence, all tobacco control measures implemented in China to date should be reviewed, along with existing gaps and future opportunities[13].

In our study, the observation of more than 50.0% of male smokers may be related to the specific population that we surveyed. We surveyed employees of a coal enterprise in northern China, and due to factors, such as work pressure and their own education level, there may be a higher number of smokers among this population. With our health education and promotion efforts, the smoking population will be greatly improved. In 2015, Beijing adopted tobacco control laws that prohibited smoking in indoor public places nationwide and actively made provisions for smoke-free environments in hospitals, schools, and other institutions, thus causing a decline in the smoking rate of adults and adolescents in Beijing to 19.9% and 1.1%, respectively. Beijing was awarded the "World No Tobacco Day Award" twice by the World Health Organization (WHO)[18,19]. Accordingly, we should formulate and implement stricter anti-smoking regulations in this population to increase the number of people who quit smoking.

A predominant risk factor in the Chinese population for cerebrovascular and cardiovascular conditions, including representative hypertension, is a high-salt diet[20,21]. Reduction in dietary salt intake per WHO recommendations, even a modest amount, might show great benefits globally; 1.65 million cases of CVD-associated deaths can be avoided every year, along with significantly reduced expenditure for the health care systems, individuals, and their family members [22]. In our study, the proportion of high salt and low salt diets in this population was not high, and most people had a moderate intake of salt. Unlike Western countries, the majority of salt intake in Western countries comes from processed foods[23]. The salt intake of Chinese residents mainly comes from the salt added in household cooking, which determines that strengthening the popularization of salt reduction knowledge and behavior can significantly reduce the salt intake of Chinese people. In fact, as early as 2017, the Chinese government had set a goal to reduce the national salt intake by 20% by 2030[24]. Local governments such as Beijing, Shanghai, and Shandong have also organized salt reduction projects in many provinces and cities, including promoting low sodium salts and salt reduction tools. We believe that there will be a significant reduction in salt intake in the future.

As another important component of cardiovascular and cerebrovascular health behavior, active physical exercise can not only reduce blood pressure but also improve blood glucose and blood lipid levels along with other indicators[25]. In 2020, the WHO released the Guide to Physical Exercise and Sitting Behavior, which focused on avoiding sedentary behavior, increasing physical activity, and improving physical conditions. For superior health benefits, adults should do either 150-300 min of moderate-intensity or 75-150 of vigorous aerobic exercises every week and focus on strength training[26]. In our study, the population who do not participate in physical exercise on a daily basis is relatively high and shows an upward trend, which may be related to the aging of the population, as we continue to observe this group of people and their exercise behavior decreases with age. This also reminds us that with the arrival of global aging, we need to focus on the exercise status of the elderly population. It is worth mentioning that if we strictly evaluate physical exercise according to the regulations of the WHO, the proportion of people who lack exercise will be higher.

Hence, effective promotion of physical education might lead to increased physical activity in individuals, thus improving population health. Emphasis on preventing stroke is crucial since it increases the burden on public health due

Table 1 Distribution (2006-2007, 2008-2009, and 2010-2011) of ideal levels of cardiovascular and cerebrovascular health metrics for men (Kailuan study)

	2006-2007	2008-2009	2010-2011
Smoking	49.27	40.18	48.17
Salt	9.34	14.04	17.65
Physical activity	13.12	16.09	12.22
Body weight	49.17	51.94	49.40
Glucose	69.99	66.44	64.67
Total cholesterol	64.20	65.02	68.33
Blood pressure	20.55	17.04	14.68

Table 2 Distribution (2006-2007, 2008-2009, and 2010-2011) of ideal levels of cardiovascular and cerebrovascular health metrics for women (Kailuan study)

	2006-2007	2008-2009	2010-2011
Smoking	98.19	98.22	98.82
Salt	9.13	17.36	18.09
Physical activity	12.00	16.86	11.83
Body weight	61.60	64.01	62.73
Glucose	78.90	76.37	74.52
Total cholesterol	64.28	67.43	67.85
Blood pressure	36.92	42.34	37.78

to prolonged disability. The foremost objective of stroke prevention is to manage correctable risk factors like arterial hypertension, a prime contributor to stroke. Therefore, appropriate measures for controlling blood pressure are mandatory for the hypertensive population[27]. According to the WHO, raised blood pressure affects > 1 billion adults globally, with an annual mortality of 9 million individuals, and is considered the chief physiological risk factor for angiocardiopathies[28]. Early and timely interventions for hypertension and comorbidities can reduce the higher expenditures for chronic diseases (*e.g.*, angiocardiopathies and cerebrovascular conditions), as well as quality-of-life deterioration[29].

The WHO formulated the Global NCD Action Plan 2013-2020, which consisted of objectives and a draft framework for holistic monitoring for preventing and controlling noninfectious diseases worldwide. Based on this, it also initiated a joint action with other member countries, the United Nations, as well as other global partners, to lower the smoking rate and the mean sodium consumption by 30% among all individuals aged ≥ 15 years and the entire population by 2025, respectively. Additionally, the prevalence rates of diabetes and obesity as well as elevated blood pressure are reduced by 10% and 25% in the underactive population. Furthermore, the risk of premature death from chronic non-communicable diseases such as CVD is relatively reduced by 25%[30,31].

Although our study was a cross-sectional study, this is an important supplement to databases in related fields, which can provide a basic reference for future research. Our next step should be to enhance the proportion of ideal cerebrovascular and cardiovascular health parameters and behaviors among this subset of the population through intervention-strengthening techniques.

CONCLUSION

The prevalence of ideal cerebrovascular and cardiovascular health parameters and behaviors is low in the Kailuan study population due to inadequate scores of relevant health metrics.

Table 3 Distribution (2006-2007, 2008-2009, and 2010-2011) of cardiovascular and cerebrovascular health score for men (Kailuan study)

Score	Proportion (%)		
	2006-2007	2008-2009	2010-2011
0			0.01
1			0.05
2	0.03	0.23	0.28
3	0.64	0.95	0.92
4	1.84	2.60	2.59
5	4.43	5.60	5.69
6	8.52	10.38	10.46
7	13.77	15.67	15.32
8	18.61	19.61	18.85
9	20.66	18.90	18.22
10	17.43	13.82	14.90
11	9.74	8.03	8.61
12	3.59	3.47	3.39
13	0.52	0.62	0.62
14	0.08	0.05	0.08
Average score	8.46	8.18	8.21

Table 4 Distribution (2006-2007, 2008-2009, and 2010-2011) of cardiovascular and cerebrovascular health score for women (Kailuan study)

Score	Proportion (%)		
	2006-2007	2008-2009	2010-2011
0			0.01
1		0.13	0.06
2		0.06	0.04
3	0.04	0.06	0.10
4	0.24	0.29	0.35
5	0.88	0.99	1.36
6	2.16	2.90	3.22
7	4.98	5.11	6.28
8	10.18	9.27	10.08
9	16.31	14.12	15.74
10	20.95	19.83	20.24
11	23.97	22.89	23.18
12	17.40	18.23	14.96
13	2.65	5.63	3.94
14	0.26	0.66	0.54
Average score	10.02	10.12	9.90

Table 5 Body mass index, blood pressure, fasting blood glucose, and total cholesterol levels of men from 2006 to 2011

	Men (mean ± SD)		
	2006-2007	2008-2009	2010-2011
Body mass index	25.21 ± 3.43	25.02 ± 3.39	25.27 ± 3.37
Systolic blood pressure, mmHg	128.63 ± 18.13	129.16 ± 17.43	128.88 ± 16.03
Diastolic blood pressure, mmHg	83.28 ± 11.18	84.65 ± 10.93	84.56 ± 10.19
Fasting blood glucose, mg/dL	97.27 ± 25.62	99.95 ± 26.57	99.93 ± 24.59
Total cholesterol, mg/dL	187.22 ± 45.38	192.25 ± 51.24	185.51 ± 36.82

Table 6 Body mass index, blood pressure, fasting blood glucose, and total cholesterol levels of women from 2006 to 2011

	Women (mean ± SD)		
	2006-2007	2008-2009	2010-2011
Body mass index	24.34 ± 3.66	24.14 ± 3.61	24.25 ± 3.53
Systolic blood pressure, mmHg	121.97 ± 17.51	119.8 ± 17.14	120.75 ± 16.45
Diastolic blood pressure, mmHg	78.23 ± 10.1	77.86 ± 9.94	78.23 ± 9.83
Fasting blood glucose, mg/dL	94.14 ± 24.34	95.86 ± 27.35	95.84 ± 22.94
Total cholesterol, mg/dL	189.02 ± 37.91	187.28 ± 54.75	186.62 ± 46.8

FOOTNOTES

Author contributions: Yu Y, Liu ZJ, and Wu SL designed the research study; Yu Y, Zhang ZX, Liu ZJ, and Wu SL performed the research; Yin SF was responsible for statistical analysis; Yu Y was responsible for drafting of the manuscript; Wu SL and Liu ZJ contributed equally to this work as co-corresponding authors; and all authors have read and approved the final manuscript.

Supported by the Peking University People's Hospital Talent Introduction Scientific Research Launch Fund, No. 2022-T-02.

Institutional review board statement: The study was reviewed and approved by the ethics committee of Kailuan Hospital (Approval No. 2006-05).

Informed consent statement: All study participants, or their legal guardian, provided informed written consent prior to study enrollment.

Conflict-of-interest statement: The authors declare that they have no conflict of interest to disclose.

Data sharing statement: Data that support the findings of this study are available from the corresponding author upon reasonable request and approval.

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S-Editor: Chen YL
L-Editor: Wang TQ
P-Editor: Zheng XM

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