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Clustering of cardiovascular disease biological risk factors among older adults in Shenzhen City, China: a cross-sectional study

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ABSTRACT

Objectives Few studies reported the clustering of cardiovascular disease (CVD) biological risk factors among older adults. The objective of this study was to characterise the clustering of CVD biological risk factors among adults aged 65 or older in Shenzhen city, China.

Design Cross-sectional study.

Setting General communities in Shenzhen, Guangdong, China.

Participants A representative sample of 5635 participants aged 65 or older participated in the survey with a response rate of 93.6%.

Main outcome measures Individual CVD biological risk factors (overweight/obesity, central obesity, hypertension, dyslipidaemia and diabetes) and their clustering.

Results The prevalence of overweight, obesity, central obesity, hypertension, dyslipidaemia and diabetes in this study was 37.4%, 10.8%, 37.0%, 51.9%, 40.2% and 18.0%, respectively. The mean count of CVD biological risk factors per participant was 1.95. The 86.0% of the participants presented at least one CVD biological risk factor and 33.8% of the participants presented clustering of CVD biological risk factors, that is, presenting three or more CVD biological risk factors, as defined in this study. Multivariable logistic regression analysis showed that gender, age, and drinking and smoking status were significantly associated with clustering of CVD biological risk factors ($P<0.05$). Women, the older and alcohol drinkers were more likely to have clustering of CVD biological risk factors.

Conclusions The prevalence of CVD biological risk factors is fairly high in the older adults with a tendency of clustering in Shenzhen. The findings highlight the need for integrated management of CVD biological risk factors among older adults.

Strengths and limitations of this study

- This is the first community-based study examining the clustering of cardiovascular disease (CVD) biological risk factors and its associated factors in Shenzhen.
- Our focus on older adults, which is considered to be a vulnerable group, is especially important in China where the proportion of older adults is increasing.
- We conducted this study with a large population-based sample, and the response rate was high.
- We obtained the lifestyle behaviour information through self-reported questionnaires, and so the information might be subjected to recall bias.
- We did not collect data on dietary habits, which may play a role in CVD biological risk factors clustering.

INTRODUCTION

According to the WHO,[1] deaths caused by non-communicable diseases (NCDs) accounted for 70% of total global deaths. Cardiovascular disease (CVD) is the leading cause of NCDs worldwide.[1] The burden of CVD is also considerable in China. According to the *Statistical Yearbook* in China, CVD was the top cause of deaths in urban areas in China in 2016.[2] Mortality risk increases with age in people with CVD.[3]

Dyslipidaemia, diabetes, hypertension, overweight/obesity and central obesity are recognised as major biological risk factors for CVD and also for other conditions. Although each of these risk factors represents unique alterations in cardiovascular risk, clustering of two or more risk factors are common in the population.[4 5] For example, 60% of patients with hypertension suffer from diabetes, and 73% suffer from dyslipidaemia.[6] Two or more of these risk factors frequently coexist in some form.[5] Previous studies have indicated that the presence of multiple risk factors additively increases the risk of CVD.[7] While traditional disease management and previous epidemiology studies in China have focused on individual diseases, there is robust evidence that concurrent comorbidities, especially the presence of any combination of dyslipidaemia, diabetes and hypertension, obesity, and central obesity, result in even higher risk for the development of CVD than

the presence of each risk factor alone. Thus, in order to implement integrated management of CVD, it is imperative to understand the clustering of CVD biological risk factors.

According to a previous study,[8] the presence of at least three CVD biological risk factors in one individual was regarded as a clustering phenomenon. Several studies have reported the clustering of CVD biological risk factors,[9–11] but few studies reported the clustering of CVD biological risk factors among older adults. In China, 10.8% of the total population, or 150 million people, were 65 or older in 2016.[2] Therefore, the aim of this study is to examine the clustering of CVD biological risk factors among people aged 65 or older in Shenzhen city, China, which may help develop an integrated strategy for future intervention and prevention of CVD in older adults.

MATERIALS AND METHODS

Study population

In a large cross-sectional study, we used the method of multistage multistratified cluster sampling to select a representative sample in Nanshan and Luohu district, Shenzhen city. In the first stage, we selected the sample by district and population distribution on the basis of Shenzhen population census data from 2010, randomly selecting 41 communities from those two districts. In the second stage, we randomly selected about 200 households from each residential community that was selected in the earlier stage. In the last stage, we chose eligible family members from each designated household and recruited participants from the selected households from April 2017 to October 2017. The eligibility criteria for participants were: (1) aged 65 or older and (2) have lived in Shenzhen for more than half a year. Information relevant to the inclusion criteria was extracted from interview records.

From April 2017 to October 2017, we had selected a total of 5635 participants and invited them to participate in the study. We asked the participants to complete a questionnaire, provide a fasting blood sample and attend physical examinations including measurement of weight, height, waist circumference (WC), systolic blood pressure (SBP) or diastolic blood pressure (DBP). Three hundred and fifty-nine participants were excluded because they did not complete the questionnaire, provide fasting blood sample or were unable to attend physical examinations. At last, 5276 participants (93.6%) were included in the final data analysis. We provided all eligible participants with health education about CVD and potential role of CVD biological risk factors, counselled participants with abnormal findings from physical examinations or laboratory testing as defined below and referred them to the nearest health facility for healthcare and follow-up. The ethics committee of the Center for Chronic Disease Control of Shenzhen approved the study. We performed all procedures in accordance with ethical standards and obtained written informed consent from all participants after informing them about the objectives, benefits, medical items and confidentiality agreement of personal information. If the participants were illiterate, we obtained written informed consent from their proxies.

Questionnaire data collection

Before collecting questionnaire data, all investigators attended organised training sessions. The training contents included the purpose of this study, how to properly administer questionnaires, the standard measurement methods, the importance of standardisation and the study procedures.

We administered structured questionnaires to collect information on sociodemographic characteristics and health parameters, and interviewed participants in person 1 hour after blood collection. Each questionnaire took approximately 20 min to complete. The questionnaire included four sections: participant demographics, lifestyle behaviours, medical history and medication use. In this study, we defined the term ‘moderate to vigorous intensity physical activity’ as at least some sweating and shortness of breath caused by physical activity, and the term ‘light physical activity’ as no sweating or shortness of breath caused by physical activity.[12] In addition, moderate to vigorous intensity physical activity at least once a week was classified as ‘Yes’ in physical activity status. For alcohol drinking habits, participants reported themselves as habitual drinker (drink once a day or more), non-habitual drinker (six times a week to once a month) or non-drinker (almost never).[13] For cigarette smoking, we categorised participants as current smoker, ex-smoker and never-smoker, as described elsewhere.[14]

Physical examination

Anthropometric measurements were administered in the morning after an overnight fasting, following which body measurements were taken by trained examiners based on a standardised protocol. Height and weight were measured with the participants wearing light dress without shoes using analogue scales. WC was measured, at the end of normal expiration, at the midpoint level of midaxillary line between the 12th rib head and the superior anterior iliac spine. Body mass index (BMI) was calculated by dividing body weight (in kilograms) by the square of height (in metres). Blood pressure was measured using a mercury sphygmomanometer on the right arm of each participant in a comfortable sitting position after a 5 min rest period. Three consecutive blood pressure measurements were performed, and the mean of these three measurements was applied in the subsequent analysis.

Blood sample collection and biochemical analyses

Vein blood samples were collected after 10–14 hours of fasting. Each glass automatic haemostix was marked with the volunteer’s identification code and placed into ice in a portable refrigerator for transport to the laboratory. In the laboratory, the blood samples were separated by centrifugation at 1000×g for 15 min at 4°C,

and then supernatant serum was collected for analysing the concentrations of blood lipids, glucose and other biochemical markers. Serum glucose, total cholesterol (TC), triglyceride (TG), low density lipoprotein cholesterol (LDL-C) and high density lipoprotein cholesterol (HDL-C) concentrations were measured using commercially available kits (Olympus System Reagents, Olympus Diagnostica, Clare, Ireland) and an autoanalyzer (Olympus AU400 System, Olympus, Tokyo, Japan). Fresh fasting blood samples were biochemically analysed within a maximum of 4 hours.

Definitions of obesity, hypertension, dyslipidaemia, diabetes and the clustering of CVD biological risk factors

Obesity was defined according to BMI based on Chinese-specific cut-off points.[15] Accordingly, obesity was defined as BMI ≥28 kg/m^2, overweight as BMI of 24–27.9 kg/m^2 and normal weight or underweight as BMI <23.9 kg/m^2.[15] Central obesity was defined as WC >95 cm for men or WC >90 cm for women.[15]

Participants with mean SBP ≥140 mmHg and/or mean DBP ≥90 mmHg were considered having hypertension, and those who were using antihypertensive medication were also considered having hypertension.[16]

High TC, hypertriglyceridemia (high TG), low HDL-C, high LDL-C and those who were receiving treatment for dyslipidaemia were considered having dyslipidaemia.[17] According to Chinese criteria,[17] participants with TC ≥6.22 mmol/L were considered having high TC, those with serum TG ≥2.26 mmol/L were considered having high TG, those with serum HDL-C <1.04 mmol/L were considered having low HDL-C and those with serum LDL-C ≥4.14 mmol/L were considered having high LDL-C. Diabetes was defined as fasting blood glucose (FBG) ≥7.0 mmol/L or self-reported treatment of diabetes with antidiabetic medication in the previous 2 weeks.[18]

Clustering of CVD biological risk factors was defined as presenting three or more CVD biological risk factors (including dyslipidaemia, diabetes, hypertension, overweight/obesity and central obesity).[8 19]

Statistical analyses

We used mean±SD to describe distribution of continuous variables and used percentage in categorical variables. We used Student's t-test to evaluate mean difference between men and women in BMI and other anthropometric measures and evaluated the proportion difference among categorical variables by χ^2 test or Fisher's exact test when appropriate.

We adopted a multivariable logistic regression model, defining the clustering of CVD biological risk factors as a dependent variable and gender, age, physical activity, drinking and smoking status as independent variables. All data analysis was performed using SPSS V.21.0. A level of two-sided P<0.05 was considered to be statistically significant.

Participant involvement statement

Participants were not involved in the design of this study. All the participants had the option to receive the health check and biochemical results if they provided their telephone number or other contact information.

Table 1 Sociodemographical and physiological characteristics of participants in the study

Variables	Both genders (n=5276)	Men (n=2342)	Women (n=2934)	t /χ^2 value	*P* value
Age*, years	71.7±5.8	71.6±5.8	71.9±5.8	2.15	0.032
Age group, n (%)				5.89	0.117
65–69	2450 (46.4)	1046 (44.7)	1404 (47.9)		
70–74	1345 (25.5)	622 (26.5)	723 (24.6)		
75–79	822 (15.6)	368 (15.7)	454 (15.5)		
≥80	659 (12.5)	306 (13.1)	353 (12.0)		
BMI*, kg/m^2	24.0±3.3	24.0±3.1	24.1±3.4	−1.42	0.155
WC*, cm	84.4±18.4	85.3±8.8	83.8±23.3	2.90	0.004
SBP*, mm Hg	135.7±18.9	134.5±18.3	136.7±19.4	−4.08	<0.001
DBP*, mm Hg	77.1±10.9	78.5±10.8	76.1±10.8	8.17	<0.001
FBG*, mmol/L	6.0±1.8	6.0±1.7	6.1±1.8	−1.77	0.077
TC*, mmol/L	5.4±1.2	5.1±1.1	5.6±1.2	−14.47	<0.001
TG*, mmol/L	1.6±1.0	1.5±0.9	1.7±1.0	−5.59	<0.001
HDL-C*, mmol/L	1.5±2.2	1.5±2.1	1.6±2.2	−2.22	0.027
LDL-C*, mmol/L	3.1±0.9	3.0±0.9	3.2±0.9	−9.40	<0.001

*Mean±SD.
BMI, Body mass index; DBP, diastolic blood pressure; FBG, fasting blood glucose; HDL-C, high density lipoprotein cholesterol; LDL-C, low density lipoprotein cholesterol; SBP, systolic blood pressure; TC, total cholesterol; TG, triglyceride; WC, waist circumference.

RESULTS

Sociodemographic and other characteristics of participants

We summarise the sociodemographical and other characteristics of the participants in table 1. Of the 5276 participants, 44.4% were men, with a mean age of 71.7±5.8 for all the participants. The means of BMI, WC, SBP and DBP were 24.0±3.3 kg/m^2, 84.4±18.4 cm, 135.7±18.9 mmHg and 77.1±10.9 mmHg, respectively (table 1). The mean concentrations of FBG, TC, TG, HDL-C and LDL-C were 6.0±1.8, 5.4±1.2 mmol/L, 1.6±1.0 mmol/L, 1.5±2.2 mmol/L and 3.1±0.9 mmol/L, respectively (table 1). There were significant differences between men and women in age, WC, SBP, DBP, TC, TG, HDL-C and LDL-C (table 1).

Prevalence of CVD biological risk factors and unhealthy lifestyles

The prevalence of overweight, obesity, central obesity, hypertension, dyslipidaemia and diabetes in this study was 37.4%, 10.8%, 37.0%, 51.9%, 40.2% and 18.0%, respectively (table 2). The prevalence of obesity, central obesity, hypertension and dyslipidaemia in women was significantly higher than that in men (table 2). As shown in table 2, habitual drinker, non-habitual drinker, current smoker and ex-smoker in participants accounted for 2.6%, 11.2%, 7.7% and 2.8% of the sample, respectively, and there were significant differences between men and women.

Clustering of CVD biological risk factors

Of these five CVD biological risk factors (overweight/obesity, central obesity, hypertension, dyslipidaemia and diabetes), 86.0% of the participants presented one or more CVD biological risk factors. Among them, approximately three-fifths (60.8%) presented two or more CVD biological risk factors, one-third (33.8%) presented three or more CVD biological risk factors and one in 10 (12.2%) presented four or more CVD biological risk factors (data not shown). The average count of CVD biological risk factors per participant in

Table 2 Prevalence of cardiovascular disease biological risk factors in Shenzhen adults aged 65 or older

Factor	Both genders (n=5276)	Men(n=2342)	Women(n=2934)	χ^2 value	*P* value
Body mass index categories, n (%)				8.27	0.016
Obesity	567 (10.8)	220 (9.4)	347 (11.8)		
Overweight	1975 (37.4)	898 (38.3)	1077 (36.7)		
Normal weight or underweight	2734 (51.8)	1224 (52.3)	1510 (51.5)		
Central obesity, n (%)				83.19	<0.001
No	3323 (63.0)	1634 (69.8)	1689 (57.6)		
Yes	1953 (37.0)	708 (30.2)	1245 (42.4)		
Hypertension, n (%)				8.46	0.004
No	2540 (48.1)	1180 (50.4)	1360 (46.4)		
Yes	2736 (51.9)	1162 (49.6)	1574 (53.6)		
Dyslipidaemia, n (%)				39.09	<0.001
No	3156 (59.8)	1511 (64.5)	1645 (56.1)		
Yes	2120 (40.2)	831 (35.5)	1289 (43.9)		
Diabetes, n (%)				1.37	0.247
No	4324 (82.0)	1936 (82.7)	2388 (81.4)		
Yes	952 (18.0)	406 (17.3)	546 (18.6)		
Physical activity, n (%)				6.05	0.014
Yes	3994 (75.7)	1811 (77.3)	2183 (74.4)		
No	1282 (24.3)	531 (22.7)	751 (25.6)		
Drinking status, n (%)				431.42	<0.001
Non-drinker	4549 (86.2)	1764 (75.3)	2785 (94.9)		
Non-habitual drinker	592 (11.2)	454 (19.4)	138 (4.7)		
Habitual drinker	135 (2.6)	124 (5.3)	11 (0.4)		
Smoking, n (%)				628.92	<0.001
Non-smoker	4724 (89.5)	1820 (77.7)	2904 (99.0)		
Ex-smoker	145 (2.8)	135 (5.8)	10 (0.3)		
Current smoker	407 (7.7)	387 (16.5)	20 (0.68)		

Table 3 Age and gender-specific clustering of CVD biological risk factors in Shenzhen adults aged 65 or older

Variables	Clustering (n=1782)	Non-clustering (n=3494)	χ^2 value	P value
Age group, n (%)			4.82	0.186
65–69	795 (32.4)	1655 (67.6)		
70–74	456 (33.9)	889 (66.1)		
75–79	296 (36.0)	526 (64.0)		
≥80	235 (35.7)	424 (64.3)		
Gender, n (%)			32.32	<0.001
Men	694 (29.6)	1648 (70.4)		
Women	1088 (37.1)	1846 (62.9)		

this study was 1.95. Consistent with a previous study, clustering of CVD biological risk factors was defined as presenting three or more CVD biological risk factors.[8] Age and gender-specific clustering was shown in table 3. The clustering of CVD biological risk factors in women was significantly higher than that in men. We evaluated the independent factors that could potentially influence the clustering of CVD biological risk factors by a multivariable logistic regression model. The results suggested that the variables of gender, age, smoking and drinking status were significantly associated with the clustering of CVD biological risk factors (table 4).

Table 4 Multivariable logistic regression analysis of clustering of CVD biological risk factors

Variables	OR (95% CI)	P value
Gender		
Women	Reference	
Men	0.69 (0.61 to 0.79)	<0.001
Age groups		
65–69	Reference	
70–74	1.08 (0.93 to 1.24)	0.316
75–79	1.20 (1.01 to 1.41)	0.036
≥80	1.21 (1.01 to 1.45)	0.044
Physical activity		
Yes	Reference	
No	0.91 (0.80 to 1.05)	0.195
Smoking		
Non-smoker	Reference	
Ex-smoker	0.59 (0.40 to 0.89)	0.012
Current smoker	0.93 (0.73 to 1.18)	0.534
Drinking status		
Non-drinker	Reference	
Non-habitual drinker	1.32 (1.08 to 1.60)	0.006
Habitual drinker	1.54 (1.06 to 2.23)	0.024

Clustering of CVD biological risk factors was defined as presenting three or more of CVD biological risk factors (including dyslipidaemia, diabetes, hypertension, overweight/obesity and central obesity); physical activity: moderate to vigorous intensity physical activity at least once a week was classified as 'Yes' in physical activity status.

DISCUSSION

This is the first population-based survey to report the clustering of CVD biological risk factors in Shenzhen adults aged 65 or older. This study demonstrates that the prevalence of CVD biological risk factors is fairly high with a tendency of clustering, which is one of the public health problems in Shenzhen. Specifically, approximately one in three participants presented three or more CVD biological risk factors, and one in 10 participants presented four or more CVD biological risk factors. After the confounding factors were controlled, the clustering of CVD biological risk factors was associated with gender, age, and drinking and smoking status.

The major finding of this study was that the prevalence of CVD biological risk factors was fairly high with a tendency of clustering. Several previous epidemiological studies reported the clustering of CVD biological risk factors in Chinese populations.[20–22] For example, the Chinese Physiological Constant and Health Condition survey measured CVD risk factors in a nationally representative sample of 23 010 Chinese aged 18 or older and provided the best comparison data for our study.[20] When compared with the findings from the Chinese Physiological Constant and Health Condition survey, the clustering of CVD risk factors in Shenzhen was worse than average Chinese national estimates (16.7%).[20] Also other regional studies have previously examined the clustering of CVD risk factors in local residents. Wang *et al* reported that 30.5% of Changchun male employees and 18.5% of Changchun female employees presented clustering of two risk factors.[21] In another regional study of 39,840 Chinese adults aged 18 or older from the 2011 Nanjing Chronic Disease and Risk Factor Surveillance, 14.4% of the participants presented at least three CVD risk factors.[22] Compared with these three studies mentioned above,[20–22] a higher proportion of Shenzhen residents presented clustering of three or more CVD risk factors. The reported phenomenon of clustering of CVD risk factors varied across these studies, depending on the diagnostic criteria used and the studied population.

Clustering of CVD risk factors has also been observed in other countries that have experienced rapid socioeconomic growth like China. Clustering of three or more CVD risk factors was presented in 22.7% of men and 21.7% of women in South Korea.[23] The proportion of adults with at least three CVD risk factors was 23.9% in Southwest Nigeria.[11]

Our study showed that women were more likely, compared with men, to present three or more CVD biological risk factors. In addition, the prevalence of clustering of CVD biological risk factors increased with age. These findings were in accordance with other previous studies.[11 20 24] The gender discrepancy in CVD biological risk factor clustering did exist in other countries. In both South Korea and Malaysia,[11 24] the prevalence of

obesity in women was significantly higher than that in men, and the clustering of CVD biological risk factors was more common in women. Our results of the progressive increase of CVD biological risk factors clustering with age may be attributed to the increasing prevalence of each risk factor with age.

The significantly higher prevalence of three or more CVD biological risk factors among drinker, compared with non-drinkers, reflected the fact that most CVD biological risk factors investigated in this study were more prevalent among drinkers, which was consistent with other reports.[25] A possible reason for this observation is as follows: drinkers may attend more social occasions and eat out more frequently, which may result in higher consumption of high-salt, high-fat and high-calorie foods, leading to increased risk of hypertension, diabetes, dyslipidaemia, overweight/obesity and central obesity. Our study also showed that never-smoking status was negatively associated with the clustering of CVD biological risk factors, which was consistent with previous studies.[26] The possible reason was that never-smokers might pay more attention to their own physical health.

Our study revealed that being women, older age and alcohol consumption were positively associated with CVD biological risk factor clustering, compared with their counterparts. Those findings from this study may help the development of health policy and interventions of CVD biological risk factors. For example, women, older adults and alcohol drinker could be screened for the clustering of CVD biological risk factors and be targeted for early prevention programmes, because they are more likely to present clustering of CVD biological risk factors.

There were several limitations in this study. First, we obtained the lifestyle behaviour information through self-reported questionnaires, and so the information might be subjected to recall bias.[27] Second, we did not obtain data on dietary habits, such as food frequency, daily consumption of fruit and vegetables, and fat intake. Future studies with more detailed information on dietary habits are warranted.

CONCLUSIONS

In summary, this cross-sectional study explores the prevalence and clustering of CVD biological risk factors in Shenzhen. Our analyses indicate that women, older adults and alcohol drinkers are most susceptible to CVD biological risk factor clustering. Appropriate public health programmes targeting CVD risk factors are required to address CVD biological risk factor clustering in the Chinese older population.

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Contributors WN and RW are joint first authors. WN and HC conceived and designed the experiment; DL, HL and JS performed the experiments; XY and RW analysed the data; and JX provided reagents/materials/analysis tools. WN and RW wrote the manuscript, and all authors reviewed and approved the final manuscript.

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Competing interests None declared.

Patient consent for publication Not required.

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