Risk Factors for Cardiovascular Disease in the Elderly in Taiwan

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The major objective of the present study was to identify biologic and behavioral risk factors of cardiovascular disease (CVD) in the elderly population in Taiwan. It is hypothesized that the selected risk factors are significantly associated with the prevalence of CVD. Data came from a nationwide geriatric survey in 1991. Stratified proportional sampling was used to recruit 2,600 subjects. These were evaluated by family physicians working for the Departments of Family Medicine at four medical centers in four major cities in Taiwan. Univariate and multivariate logistic regression analyses were used to examine the associations between risk factors and the prevalence of CVD. The prevalence of CVD was 38.31%. Patients with CVD consistently had higher values for each selected risk factor except high-density lipoprotein-cholesterol (HDL-C) and glucose concentrations. The findings also indicated that hypertension, hypertriglyceridemia, low HDL-C concentration, ex-drinking status, and overweight were significantly associated with the prevalence of CVD among the elderly in Taiwan. The findings not only confirm the risk factors for CVD, but also invite more attention to be given to the importance of biologic and behavioral risk factors in CVD.

Key Words: cardiovascular disease, risk factors, elderly, prevalence
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The lifestyle in Taiwan has changed dramatically with recent rapid economic growth. Consequently, the major causes of mortality have changed from infectious diseases to chronic diseases. Among chronic diseases, heart disease is life-threatening and was ranked as the third leading cause of death in Taiwan in 1991. The mortality rate for heart disease increased from 37.38 per 100,000 in 1988 to 41.75 per 100,000 in 1991 [1]. The prevalence of heart disease increases with age, especially for coronary heart disease (CHD) [2,3]. In Taiwan, the proportion of people aged 65 years and over reached 7.8% in 1997 [4]. Developing effective and efficient prevention and treatment programs for cardiovascular disease (CVD) has been a major focus of public health and clinical research.

To identify the determinants of CVD for health services planning, many epidemiologic studies have focused on the influence of specific biologic factors, whereas others have examined behavioral and lifestyle factors. However, information on the risk factors for CVD and their prevalence among the elderly in Taiwan is limited.

The first community-based study of the prevalence of heart disease in Taiwan was conducted by Tsai et al in 1965 using a cross-sectional design in a small rural aborigine township in central Taiwan [3]. Later studies contributed information on the prevalence of heart disease, especially CHD, which ranged from 3.1% to 3.5% without significant variation [5–7]. However, epidemiologic studies limited

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samples to residents of northern Taiwan and only focused on the general population. The prevalence of CHD in Taiwan was similar to those in other Asian countries [8], and almost 50% less than the prevalence in Western countries [9–11]. The prevalence of other types of heart disease, such as hypertensive CVD (HCVD), has not been examined in Taiwan. The measurement of various manifestations is not easy, so the present study focused on the prevalence of total CVD.

The association of biologic risk factors with CVD has been studied extensively in developed countries. Hypertension, hypercholesterolemia, low high-density lipoprotein-cholesterol (HDL-C) concentration, high low-density lipoprotein-cholesterol (LDL-C) concentration, hypertriglyceridemia, and diabetes mellitus are well established determinants of CVD [8,10,12–17]. Although similar findings were found in several studies in Taiwan [18–22], most studies confined their samples to the hospital setting or did not focus on community elderly.

In addition to biologic risk factors for CVD, increasing attention is called to behavioral risk factors. Many epidemiologic studies have demonstrated positive associations between alcohol intake, smoking, physical inactivity, and obesity with the prevalence of CVD [14,17, 23–27]. There is a positive association between heavy drinking and the prevalence of CVD [25–27], although several studies have reported that light to moderate alcohol intake can provide protection against CVD [2,27,28]. In Taiwan, not much effort has been made to study behavioral risk factors for CVD, particularly focusing on the elderly population.

The major aim of the present study was to identify biologic and behavioral risk factors for CVD among the elderly in Taiwan based on the data collected by the nationwide geriatric epidemiologic survey in 1991 [29].

Materials and Methods

Sample and data

Data were derived from a nationwide geriatric survey funded by the Department of Health, Taiwan, in 1989–1991. The nationwide survey was conducted by the Departments of Internal Medicine and Family Medicine of three medical centers and one regional hospital in four major cities in Taiwan: Taipei, Taichung, Kaohsiung, and Hualien. The original purpose of the geriatric epidemiologic study was to evaluate the lifestyle, disease patterns, and health status of community elderly aged at least 65 years. Stratified proportional sampling was used to recruit the sample. The response rates for each geographic area were as follows: northern areas, 48.9%; central areas, 37.3%; southern areas, 63.1%; and eastern areas, 47.9%.

Sampled subjects were invited to the designated medical centers for a comprehensive health status examination combined with physical, neurologic, and laboratory evaluations [29]. At the same time, a questionnaire was administered by physicians to assess medical history, alcohol consumption, and cigarette smoking. Home visits and assessments were arranged for subjects with transportation problems. A total of 1,417 subjects were included in northern Taiwan, 400 in central Taiwan, 500 in southern Taiwan, and 283 in eastern Taiwan. A total of 2,600 subjects who completed the survey between April 1989 and June 1991 served as the data source for the present study.

Validity and reliability of data

To enhance the validity and reliability of the data, National Taiwan University Hospital (NTUH) served as the quality control center. To control the technical equipment and operational procedures, all the laboratory, X-ray, and electrocardiogram (ECG) samples were delivered to NTUH for examination and interpretation. Blood samples collected in other designated medical centers were delivered to NTUH on the day of collection. ECGs were examined by two professors using the same established criteria. Therefore, variations in the results from sample to sample were assumed to be minimized.

Measurement

Different types of CVD were included in the present study: HCVD, CHD (i.e. angina pectoris and myocardial infarction), cardiac dysrhythmias, rheumatic heart disease, heart failure, and other heart diseases. To be classified in the CVD group, subjects had to meet the following criteria. First, subjects with self-reported heart problems were confirmed by history from medical records. Second, subjects with self-reported heart problems but no CVD medical history were confirmed by ECG changes. Finally, subjects with at least one of the listed heart diseases were included in the CVD group, while all other subjects were considered to be in the non-CVD group for further analyses.

The normality thresholds for the examined risk factors are presented in Table 1, grouped into biologic and behavioral factors. Hypertension, hypercholesterolemia, low HDL-C concentration, high LDL-C concentration, hypertriglyceridemia, and diabetes mellitus were considered biologic (biochemical) factors or clinical parameters. For the

Table 1. Definitions of cardiovascular disease risk factors

	Definition
Biologic risk factor	
Hypertension	SBP ≥ 160 mmHg or DBP ≥ 95 mmHg or Use of any antihypertensive drugs on a regular basis
Hypercholesterolemia	Fasting serum cholesterol ≥ 240 mg/dL
Hypertriglyceridemia	TG ≥ 200 mg/dL
Low HDL-C	HDL-C < 35 mg/dL
High LDL-C	LDL-C ≥ 160 mg/dL
Diabetes	Fasting serum glucose ≥ 140 mg/dL or Treatment with oral hypoglycemic drug or insulin
Behavioral risk factor	
Heavy smoker	≥ 20 cigarettes/day
Ex-smoker	Quit smoking for > 6 months
Overweight	BMI ≥ 25 kg/m^2

SBP = systolic blood pressure; DBP = diastolic blood pressure; TG = triglyceride; HDL-C = high-density lipoprotein-cholesterol; LDL-C = low-density lipoprotein-cholesterol; BMI = body mass index.

behavioral or lifestyle factors, heavy smoker, ex-smoker, and overweight were examined. Subjects who had quit smoking more than 6 months previously were considered ex-smokers. Body mass index (BMI) was used to measure overweight: a subject with a BMI of at least 25 was included as overweight.

In addition to biologic and behavioral factors, the literature evidence indicates that gender and age also affect CVD prevalence [30,31]. Therefore, gender and age were used as control variables for further multivariate analyses.

Statistical analysis

Descriptive analysis and correlation were used to understand the distributions of the selected risk factors for CVD. Both univariate and multivariate logistic regression analyses were performed to evaluate the pure effect of each risk factor and the simultaneous influences of the risk factors on the prevalence of CVD, as some researchers have suggested that univariate analysis is as important as multivariate analysis [32].

RESULTS

Subjects were divided into CVD and non-CVD groups for

Table 2. Comparison of risk factors for cardiovascular disease (CVD) between subjects with and without CVD

	CVD group			Non-CVD group		
	n	Mean	SD	*n*	Mean	SD
Continuous risk factor						
Age, yr	697	71.13	4.24	1,849	71.42	4.56
SBP, mmHg	683	153.42	20.86	1,816	139.22	20.18
DBP, mmHg	684	86.89	11.69	1,817	80.45	10.63
Cholesterol, mg/dL	672	208.68	42.57	1,802	203.23	42.04
LDL-C, mg/dL	567	124.10	42.22	1,572	120.60	41.63
HDL-C, mg/dL	572	43.87	16.27	1,585	46.49	16.76
Triglyceride, mg/dL	670	140.51	79.92	1,797	118.25	73.40
Glucose, mg/dL	617	124.00	52.67	1,659	124.18	57.58
BMI, kg/m^2	666	24.75	3.43	1,783	23.69	3.56
		n (%)			*n* (%)	
Categorical risk factor						
Male gender		352 (46.87)			970 (52.46)	
Ex-smoker		40 (5.33)			76 (4.11)	
Heavy smoker		92 (12.25)			278 (15.04)	
Prevalence		996 (38.31)			1,604 (61.69)	

SD = standard deviation; SBP = systolic blood pressure; DBP = diastolic blood pressure; LDL-C = low-density lipoprotein-cholesterol; HDL-C = high-density lipoprotein-cholesterol; BMI = body mass index.

descriptive analyses. The distributions of continuous risk variables are presented in Table 2. The mean age in the two groups was similar: 71.13 ± 4.24 years in the CVD group and 71.42 ± 4.56 years in the non-CVD group. The CVD group consistently had a higher value for each variable except HDL-C and glucose concentrations. A higher percentage of female subjects and ex-smokers were also found in the CVD group. In total, the prevalence of CVD was 38.31% (n = 996).

Table 3 presents the results of univariate logistic regression analysis. Gender, but not age, had a significant association with the prevalence of CVD. Male subjects were less likely to have CVD compared with female subjects (odds ratio, OR = 0.80; 95% confidence interval, 95% CI, 0.67, 0.95). Subjects with hypertension were 6.54 times more likely to have CVD than subjects with normal blood pressure (95% CI, 5.40, 7.92). Subjects with hypercholesterolemia were 27% more likely to have CVD than subjects with normal cholesterol (95% CI, 1.02, 1.59). Subjects with hypertriglyceridemia were almost twice as likely to have CVD as subjects with triglycerides in the normal range (95% CI, 1.51, 2.56). Subjects with lower HDL-C concentrations were 36% more likely to have CVD compared with subjects who had higher concentrations. By the same token, subjects with high LDL-C concentrations were 32% more likely to have CVD. However, diabetes mellitus was not significantly associated with the prevalence of CVD.

Overweight was significantly associated with the prevalence of CVD (OR = 1.54; 95% CI, 1.29, 1.85). Yet, smoking behavior, either ex-smokers or heavy smokers, did not have a significant impact on the prevalence of CVD.

The results of multivariate logistic regression analysis are presented in Table 4. After controlling for gender and

Table 3. Univariate logistic regression analysis of cardiovascular disease in the elderly in Taiwan

Risk factor	Parameter estimate	p	Odds ratio	95% CI (lower, upper)
Gender (female = 0)	–0.21	0.015	0.80	0.67, 0.95
Age (yr)	–0.01	0.150	0.98	0.96, 1.00
Hypertension (no = 0)	1.87	0.000	6.54	5.40, 7.92
Hypercholesterolemia (no = 0)	0.24	0.031	1.27	1.02, 1.59
Hypertriglyceridemia (no = 0)	0.67	0.000	1.97	1.51, 2.56
Low HDL-C (HDL-C ≥ 35 mg/dL = 0)	0.30	0.004	1.36	1.10, 1.68
High LDL-C (LDL-C < 160 mg/dL = 0)	0.28	0.029	1.32	1.02, 1.70
Diabetes mellitus (no = 0)	–0.09	0.386	0.90	0.72, 1.13
Ex-smoker (no = 0)	0.23	0.248	1.27	0.84, 1.90
Heavy smoker (no = 0)	–0.17	0.174	0.83	0.64, 1.08
Overweight (BMI < 25 = 0)	0.43	0.000	1.54	1.29, 1.85

CI = confidence interval; HDL-C = high-density lipoprotein-cholesterol; LDL-C = low-density lipoprotein-cholesterol; BMI = body mass index.

Table 4. Multivariate logistic regression analysis of cardiovascular disease in the elderly in Taiwan

Risk factor	Parameter estimate	p	Odds ratio	95% CI (lower, upper)
Intercept	–1.32	0.128		
Gender (female = 0)	–0.14	0.231	0.87	0.69, 1.09
Age (yr)	–0.01	0.461	0.99	0.97, 1.01
Hypertension (no = 0)	1.86	0.000	6.45	4.51, 7.95
Hypercholesterolemia (no = 0)	–0.00	0.993	1.00	0.70, 1.43
Hypertriglyceridemia (no = 0)	0.41	0.012	1.50	1.09, 2.06
Low HDL-C (HDL-C ≥ 35 mg/dL = 0)	0.27	0.027	1.31	1.03, 1.66
High LDL-C (LDL-C < 160 mg/dL = 0)	0.21	0.266	1.23	0.86, 1.77
Diabetes mellitus (no = 0)	–0.05	0.702	0.95	0.73, 1.24
Ex-smoker (no = 0)	0.52	0.058	1.68	0.98, 2.87
Heavy smoker (no = 0)	–0.22	0.216	0.80	0.56, 1.14
Overweight (BMI < 25 = 0)	0.24	0.128	1.27	1.02, 1.57

The overall fit of the model was evaluated by log likelihood ratio: χ^2 = 392.091 with 11 degrees of freedom, p = 0.0001. CI = confidence interval; HDL-C = high-density lipoprotein-cholesterol; LDL-C = low-density lipoprotein-cholesterol; BMI = body mass index.

age, three of six biologic factors were significantly associated with the prevalence of CVD. Subjects with hypertension were 6.45 times more likely to have CVD than normotensive subjects (95% CI, 4.51, 7.95). Subjects with hypertriglyceridemia were 50% more likely to have CVD than subjects with normal triglyceride levels (95% CI, 1.09, 2.06). The elderly with low HDL-C concentrations were 31% more likely to have CVD compared to elderly with higher concentrations (95% CI, 1.03, 1.66). Hypercholesterolemia and high LDL-C concentrations were significant predictors in the univariate analysis, but not in the multivariate analysis. Similar to the result of univariate analysis, diabetes mellitus was not a significant predictor in the multivariate logistic regression model.

With respect to behavioral factors, overweight was significantly associated with the prevalence of CVD in the univariate analysis, but not in the multivariate analysis. Smoking status did not show significant impact on the prevalence of CVD in either the univariate or multivariate analyses.

Discussion

To identify the determinants of CVD for health services planning, the present study considered the importance of biologic and behavioral factors in CVD. The findings indicated that hypertension, hypertriglyceridemia, low HDL-C concentration, and overweight were significantly associated with the prevalence of CVD among the elderly in Taiwan according to multivariate analysis. However, the results of multivariate analysis differ from those of univariate analysis from time to time [32–34]. In this study, gender, high LDL-C concentration, and hypercholesterolemia were significant predictors in the univariate analysis, but did not exhibit significant influence in the multivariate analysis. Whether the variance in hypercholesterolemia and high LDL-C concentration is shared by other variables or reduced by the problem of collinearity needs further investigation.

Hypertension was the most significant determinant of CVD in the present study, which is not only consistent with the findings of previous studies [12–17,30,32], but also extends the generalizability to the elderly population in Taiwan. In recognition of the critical influence of hypertension on CVD, more hypertension screening programs should be applied in the community on a large scale. A positive association between elevated triglycerides and the prevalence of CHD has been found in many studies [33–39]. This study suggested that high triglycerides are a biologic risk factor for CVD in both univariate and multivariate analyses, in which cholesterol, LDL-C, HDL-C, and lifestyle factors were held constant. Low HDL-C concentration was a significant risk factor in both logistic regression models, which verified the findings of other studies in Taiwan and other countries [22,40].

The influence of cholesterol on the prevalence of CVD is controversial [19,20,22,41]. In the present study, the cholesterol level did not reach a significant level in multivariate analysis, but it was significant in univariate analysis. Several studies found that the association between triglyceride concentration and CHD was usually interrelated with cholesterol concentration, except in diabetes [42]. This may explain the source of controversy regarding the influence of cholesterol. Diabetes mellitus is a significant predictor in many studies [43–46]. However, diabetes mellitus was not a significant predictor of CVD in our study, in either univariate or multivariate analysis, which is also indicated in other studies in Taiwan [3,20]. Whether diabetes mellitus can serve as a good predictor for CVD in Taiwan needs further evaluation.

Of the behavioral factors, overweight was significantly associated with the prevalence of CVD, which is consistent with other studies [18,23]. Smoking behavior, either heavy smoker or ex-smoker, was not an influential predictor of CVD, which is consistent with the other studies in Taiwan [29] but different from Western studies [47,48]. The differences between countries require more exploration.

In conclusion, the present study confirms that hypertension, hypertriglyceridemia, and low HDL-C concentration are significant biologic risk factors for CVD, while overweight is the only behavioral risk factor for CVD. These findings not only confirm the risk factors for CVD but also enrich the literature evidence for the elderly population. However, the common weaknesses of cross-sectional study design are still inevitable. In this regard, a longitudinal study will be useful to explore cause-effect relationships between risk factors and specific diseases.

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台灣老人心血管疾病之危險因子探討

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本研究之主要目的在於探討影響台灣老人心血管疾病之生物與行為危險因子。本研究假設特定之生物與行為危險因子與心血管疾病之盛行率有顯著相關。資料來源主要取自於 1991 年全國老人醫學調查研究，利用分層比例抽樣法完成 2,600 位社區老人招募，並進一步由台灣四大主要都市的四個醫學中心家庭醫學科家庭醫師加以評估。利用單變量與多變量對數迴歸分析檢視心血管疾病盛行率與危險因子之關係。研究結果顯示，台灣老人心血管疾病之整體盛行率為 38.31%；進一步發現罹患心血管疾病之老人中，除 HDL-C 及血糖之外，其他各項特定危險因子的數值皆較高。本研究同時發現高血壓、高血脂、低 HDL-C、先前酗酒及體重過重與老人心血管疾病盛行率有顯著關係。本研究發現不僅證實心血管疾病之危險因子，而且引起更多關注於心血管疾病生物與行為危險因子的重要性。

關鍵詞：心血管疾病，危險因子，老人，盛行率

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