



Risk Factors of Cardiovascular Disease and Their Related Socio-Economical, Environmental and Health Behavioral Factors: Focused on Low-Middle Income Countries- A Narrative Review Article

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Abstract

Background: In order to decrease the burden of cardiovascular disease (CVD), social determinants for CVD risk factors have been extensively studied in developed countries. However, few studies about them have been performed in low-middle-income countries. This study describes factors related to CVD risk factors in low-middle-income countries at a national level.

Methods: Data were assembled from international databases for 47 low-middle-income countries and were collected from various sources including WHO, World Bank, and previous studies. Coefficient estimates between male and female CVD risk factor prevalence and each independent variable were calculated via linear regression.

Results: Statistically significant inverse associations were observed between adult literacy rate and systolic blood pressure, blood glucose. Pump price for gasoline was negatively associated with blood glucose also. Associations for female unemployment, adult literacy rate, paved roads and urban population, alcohol and western diet were positively associated with CVD risk factors. Unemployment, urban population and alcohol were positively associated with CVD risk factors in males.

Conclusion: The effectiveness of intervention program for the prevention of cardiovascular disease in populations in developing countries should be explored, and more attention should be given to women.

Keywords: Cardiovascular disease, Health behavior, Obesity, Ecological study

Introduction

Cardiovascular disease (CVD) is becoming a leading cause of morbidity, mortality, and disability in the world. It is becoming a large global burden. Approximately one-third of all global deaths and 10% of total DALY losses were attributed to CVD (1). For the past few decades, the majority of cardiovascular disease occurred in industrialized, higher-income countries. However, the absolute burden of cardiovascular disease has been greater in developing countries. Developing countries now experience a much greater burden of cardiovascular disease than developed countries do, so

will bear the greatest burden of cardiovascular disease in the future (2).

The relationship between CVD and risk factors such as high blood pressure, cholesterol, obesity, smoking, diabetes, and physical inactivity have been well known. In order to decrease the burden of disease associated with CVD, risk factors for CVD have been extensively studied in developed countries. Poorolajal estimated of NCDs risk factors in Iran (3), but to our knowledge, few studies focused on factors related to CVD risk factors in low-middle income countries. Furthermore, due to industrialization, globalization, urbanization,

and population ageing, there are also a number of underlying determinants of CVD, or "the related factors of risk factors". Therefore, more and more studies have documented social determinants such as economic situation, cultural change, health behavior, and lifestyle in high-income countries. However, previous studies rarely focused on these circumstances in low- and middle-income countries. And another problem is that, although the association between CVD and diabetes and health risk factors like diet, smoking, alcohol, physical inactivity and socioeconomic status has been studied within countries (4), few studies have assessed the cross-country association of CVD risk factors with national macroeconomic variables. Due to increasing urbanization and industrialization, risk factors are no more focused at individual level but are related to environmental, social and economic factors.

Therefore, our study's aim is to identify factors related to CVD risk factors encompassing various factors, like education, health environment, health behaviors, and government policy in low-middle-income countries that have not been studied previously. We did an ecological study to identify population-level patterns and dynamics with national macroeconomic variables.

Methods

Design and data sources

In order to address these research aims, we used an ecological study design using data from low-middle-income countries. The prevalence of obesity, insufficient activity, systolic blood pressure, and fasting blood glucose are risk factors of cardiovascular disease, which were evaluated in relation to national indicators of the economic, education, transportation environment, health behavior, and policy. Aggregate country-level data were assembled from several databases (Table 1) including WHO (5), The World bank (6) databases, and published articles. Initially, we collected data for all low- and middle-income countries in the study, but, later, countries with missing data of any of the indicators were excluded, leaving 47 countries for analysis. At first, we choose GINI as

one of the independent variables, but classification into low, middle and high income countries' according to GINI was not available, so we excluded high income countries according to GINI, World bank database of 2012 (7).

Dependent variables

In our study, the dependent variables included obesity prevalence, insufficient activity, blood pressure, and blood glucose. Each of the dependent variables was gender-specific. Obesity variables were self-reported prevalence rates of obesity (i.e. percentage of population with $BMI \geq 30$ kg/m²) derived from national surveys. As Table 1 shows, insufficiently active individuals were defined as attaining less than 5 times 30 minutes of moderate activity per week or less than 3 times 20 minutes of vigorous activity per week, or equivalent. Blood pressure and blood glucose is the average value by an age-standardized estimate. Countries were selected based on the availability of the four dependent variables data. The latest data of obesity and insufficient activity variable from 2008 were applied, and the data of blood pressure and blood glucose from 2009 were applied.

Independent variables

This study covered five dimensions: economic (GDP, unemployment), education (tertiary school enrollment, adult literacy rate), transportation environment (paved roads, passenger cars, pump price for gasoline, urban population), health behavior (western diet, alcohol, smoking rate), and health governance of the government (health expenditure), and it included 12 macro-environmental indicators. A 9-year time frame was applied (2004–2012) to search the database. We selected the most recent data during this period. The available variables of interest are described in Table 1, along with their sources.

Statistical method

Linear regression models were employed to examine the association between each independent variable and the risk factors of cardiovascular data, as continuous dependent variables, for male and female groups separately.

Table 1: Description of dependent and independent variables in the analysis with their sources

Indicator	Year	Unit	Description	Source
Dependent variables				
Obesity	2008	% of population	Percentage of defined population with a body mass index (BMI) of 30 kg/m ² or higher.	WHO
Insufficiently active	2008	% of population	Percent of defined population attaining less than 5 times 30 minutes of moderate activity per week, or less than 3 times 20 minutes of vigorous activity per week, or equivalent.	WHO
Mean fasting Blood glucose	2009	mmol/l	Mean fasting blood glucose (mmol/l) (age-standardized estimate)	WHO
Mean systolic Blood pressure	2009	mmg	Mean systolic blood pressure (age-standardized estimate)	WHO
Independent variables				
Economic				
GDP	2006-2012	US\$ / capita	GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars.	THE WORLD BANK
Unemployment	2005-2011	% of male labor force	Unemployment refers to the share of the labor force that is without work but available for and seeking employment. Definitions of labor force and unemployment differ by country.	THE WORLD BANK
Education				
School enrollment, tertiary	2005-2011	Per 1000 population	Gross enrolment ratio. Tertiary (ISCED 5 and 6). Total is the total enrollment in tertiary education (ISCED 5 and 6), regardless of age, expressed as a percentage of the total population of the five-year age group following on from secondary school leaving.	THE WORLD BANK
Adult literacy rate	2012	% of population	Adult literacy rate, both sexes (% aged 15 and above)	THE WORLD BANK
Transportation environment				
Paved roads	2004-2010	% of total roads	Paved roads are those surfaced with crushed stone (macadam) and hydrocarbon binder or bituminized agents, with concrete, or with cobblestones, as a percentage of all the country's roads, measured in length.	THE WORLD BANK
Passenger cars	2004-2010	Per 1000 population	Passenger cars refer to road motor vehicles, other than two-wheelers, intended for the carriage of passengers and designed to seat no more than nine people (including the driver).	THE WORLD BANK
Pump price For gasoline	2006-2012	US\$ /liter	Fuel prices refer to the pump prices of the most widely sold grade of gasoline. Prices have been converted from the local currency to U.S. dollars.	THE WORLD BANK
Urban population	2012	% of total population	Urban population refers to people living in urban areas as defined by national statistical offices. It is calculated using World Bank population estimates and urban ratios from the United Nations World Urbanization Prospects.	THE WORLD BANK
Health behavior				
Western diet	2008		Discussed in method section	Previous article ^a
Alcohol	2008	Total per capita consumption	Total (recorded + unrecorded) adult (15+ years) per capita consumption, projected estimates for 2008	WHO
Smoking rate	2009	% of total population	Current smoking of any tobacco product prevalence estimates, resulting from the latest adult tobacco use survey (or survey which asks tobacco use questions), which have been adjusted according to the WHO regression method for standardizing described in the Method of Estimation below. "Tobacco smoking" includes cigarettes, cigars, pipes or any other smoked tobacco products. "Current smoking" includes both daily and non-daily or occasional smoking	WHO
Health governance of The government				
Health expenditure	2011	% of total expenditure	General government expenditure on health as a percentage of total government expenditure	WHO

a: The Global Cardiovascular Risk Transition: Associations of Four Metabolic Risk Factors with National Income, Urbanization, and Western Diet in 1980 and 2008 by Goodarz Danaei.

The GDP indicator was transformed into a categorical variable based on quartiles and entered into a linear regression with each risk factor as a continuous dependent variable. Given the exploratory nature of our study, analyses relied on an alpha-level of 0.05 to confer statistical significance. Analyses were performed using IBM SPSS Statistics 19.

Results

Dependent variables

There was a wide variation in the prevalence of obesity and insufficiently active between genders (Table 2, 3).

Table 2: Prevalence of obesity, insufficient activity, systolic blood pressure and blood glucose for male and female groups in 47 low-middle-income countries

Country	GDP	Obesity		Insufficiently active		Systolic blood pressure		Blood glucose	
		Male	Female	Male	Female	Male	Female	Male	Female
Armenia	3338	14.4	30.2	...	...	135.2	132.6	5.7	5.6
Azerbaijan	7228	15.8	32.1	...	...	132.2	128.6	5.7	5.7
Bangladesh	747	1.0	1.3	2.7	6.6	126.4	126.0	5.4	5.5
Bolivia	2576	10.0	27.1	...	...	128.6	122.6	5.4	5.5
Bosnia and Herzegovina	4447	22.7	25.3	30.3	37.0	133.2	133.1	5.7	5.5
Brazil	11340	16.5	22.1	47.2	51.6	134.0	124.9	5.6	5.5
Bulgaria	6986	22.0	20.4	24.7	28.8	133.8	128.1	5.5	5.3
Burkina Faso	634	1.7	3.0	14.6	16.3	132.3	131.4	5.4	5.3
Cambodia	946	1.6	2.8	11.4	11.1	123.5	117.8	4.7	4.7
Cameroon	1151	7.0	15.1	33.0	48.3	131.7	127.5	5.5	5.6
Chile	15363	24.5	33.6	...	...	133.7	125.2	5.6	5.4
Costa Rica	9391	20.9	28.3	...	...	129.5	121.3	5.6	5.5
Croatia	13227	22.8	19.4	26.2	21.0	135.2	130.1	5.5	5.2
Egypt, Arab Rep.	3187	22.5	46.3	...	...	126.1	125.0	5.0	5.1
Ethiopia	470	0.9	1.6	16.5	22.1	130.2	127.2	5.1	5.0
Georgia	3508	15.9	25.7	21.1	23.5	135.4	130.5	5.7	5.6
Ghana	1605	4.4	11.7	14.4	20.8	129.5	128.1	5.5	5.5
Guatemala	3368	13.8	26.7	15.3	17.0	127.4	121.3	5.7	5.9
India	1489	1.3	2.5	12.7	18.4	123.7	123.0	5.6	5.6
Indonesia	3557	2.5	6.9	31.5	28.1	129.5	126.7	5.1	5.1
Iran, Islamic Rep.	6816	13.6	29.5	27.1	47.0	128.5	124.9	5.4	5.5
Jordan	4945	27.3	41.7	...	...	125.4	120.9	6.3	6.3
Kazakhstan	12007	20.2	27.4	32.0	31.0	134.1	128.7	5.8	5.5
Lao PDR	1399	1.7	4.1	16.7	21.0	127.1	123.9	5.1	5.1
Latvia	14009	21.5	21.8	28.1	35.9	136.5	129.3	5.5	5.3
Lithuania	14150	23.9	24.7	20.3	24.9	137.2	130.4	5.6	5.4
Malaysia	10381	10.4	17.9	57.3	65.6	127.3	123.9	5.7	5.6
Mauritius	8124	12.9	23.0	38.2	39.1	134.4	130.7	5.7	5.5
Mexico	9742	26.7	38.4	37.1	38.4	127.0	122.1	5.9	5.9
Moldova	2038	10.0	28.8	...	...	134.4	130.4	5.4	5.6
Morocco	2925	11.1	23.1	...	...	130.3	132.4	5.6	5.6
Namibia	5668	4.3	16.8	51.9	65.1	136.2	133.5	5.3	5.4
Nepal	707	1.4	1.6	13.9	17.0	125.9	126.6	5.5	5.4
Pakistan	1290	3.5	8.4	32.7	48.1	127.4	126.7	5.7	6.0
Panama	9534	19.4	32.1	...	...	130.1	122.6	5.6	5.6
Paraguay	3813	16.2	22.3	40.7	42.0	131.0	123.7	5.6	5.5
Peru	6573	11.1	21.7	...	...	125.7	119.5	4.9	4.9
Romania	7943	16.3	19.0	31.2	46.2	133.2	128.7	5.5	5.3
Saudi Arabia	20778	29.5	43.5	61.5	76.2	129.8	126.4	6.7	6.6
Senegal	1032	3.2	12.5	20.4	25.8	132.9	130.8	5.4	5.5
Serbia	5190	25.5	20.3	63.2	73.3	135.1	129.8	5.5	5.2
Tanzania	609	4.0	6.8	...	...	132.3	131.2	5.3	5.3
Turkey	10666	22.8	35.6	49.5	62.5	123.4	123.5	5.5	5.4
Ukraine	3867	15.5	23.6	20.4	16.3	137.5	131.4	5.5	5.4
Uruguay	14449	20.7	26.0	28.0	40.2	132.5	124.2	5.6	5.5
Vietnam	1596	1.2	2.0	14.6	15.9	127.4	122.4	5.2	5.2
Yemen, Rep.	1494	10.5	22.7	...	...	129.5	127.0	5.6	5.6

Obesity prevalence ranged from 0.9 to 29.5% among males, from 1.3 to 46.3% among females and a median value of 13.3% for males and 20.8% for females. Insufficiently active ranged from 2.7 to 63.2% among males, from 6.6 to 76.2% among females and a median value of 29.0% for males and 34.8% for females. Through the result, we observed more prevalence of obesity and insufficiently active in females than male. But in the blood glucose and blood pressure, we did not observe obvious differences between male and female.

Macro-environmental correlates

The sample size and distribution of the independent variables of interest are provided in Table 3. Gender specific linear regression coefficients (b) along with the p-values are presented in Table 4. Statistically significant inverse associations were observed between adult literacy rate and systolic blood pressure, blood glucose. Pump price for gasoline was negatively associated with blood glucose also. Associations for female unemployment, paved roads and urban population, alcohol and western diet were positively associated with CVD risk factors. Only three statistically significant findings for male CVD risk factors were associated with available unemployment, urban population (approximate value, $p=0.052$) and alcohol. The magnitude of the coefficient estimates suggests stronger associations for female CVD risk factors than for male CVD risk factors in all cases. Independent variables not significantly associated with CVD in any of the five groups included GDP, students in tertiary education, passenger cars, smoking, and health expenditure.

Discussion

We examined four risk factors of CVD data and found that, risk factors of CVD are influenced by socioeconomic factors, environment, and lifestyle. But we did not find any relationship for the four risk factors (obesity, insufficient activity, systolic blood pressure, and fasting plasma glucose) with GDP, although a study stated that GDP and obesity have a negative association in high-income

European countries(8). We usually consider that higher income implies that there is more money to spend on health. Through study of previous articles, various different results were found. Goodarz studied country-level CVD risk factor estimates for 199 countries and he found that associations between national income and BMI, systolic blood pressure, total cholesterol, and their outcomes for gender changed with time(9).The study indicated that a country's high or low GDP level does not indicate that there must be health behavior change and health improvement endeavors. It can be assumed that national income has a rather indirect relationship with health behavior or health improvement endeavors, not a direct relationship.

In our study, unemployment was positively associated with systolic blood pressure among men, and it showed a significant positive association with obesity, insufficient activity, and systolic blood pressure among females. Previous studies in high-income countries showed there is an association between unemployment and health-related diseases. They found that health-related consequences of unemployment can be mitigated by social support (10,11).However, in low-middle-income countries, there is scarcity of social security systems that compensate for the impact of unemployment on health. There may be several reasons for unemployment that led to higher-risk factors of CVD, especially in women more than in men. Women are often needed for housekeeping, child rearing, and so on. Due to longer stays at home, females lack outdoor activities and have easy access to food that causes obesity (12). Moreover, unemployed women suffer more mental stress than men, which can lead to hypertension (13).

We found that a lower adult literacy rate has higher risk factors of BP and blood glucose among women. Education provides knowledge and life skills that allow people to gain ready access to information and health promotion resources. A study has demonstrated a consistent association between educational level and CVD risk factors (14).

Table 3: Summary statistics (median, minimum, and maximum) for independent variables by domain across 47 low-middle countries

indicator	Number of countries	Unit	Median	Minimum	Maximum
Dependent variables					
obesity male	47	% of population	13.3	0.9	29.5
obesity female	47	% of population	20.8	1.3	46.3
Insufficiently active male	34	% of population	29.0	2.7	63.2
Insufficiently active female	34	% of population	34.8	6.6	76.2
mean fasting blood glucose male	47	mmol/l	5.5	4.7	6.7
mean fasting blood glucose female	47	mmol/l	5.5	4.7	6.6
mean systolic blood pressure male	47	mmg	130.7	123.4	137.5
mean systolic blood pressure female	47	mmg	126.7	117.8	133.5
Independent variables					
Economic					
GDP	47	US\$ / capita	5878.8	470.2	20777.7
Unemployment male	47	% of male labor force	8.1	0.3	32.5
Unemployment female	47	% of male labor force	10.8	0.1	43.0
Education					
School enrollment, tertiary	47	per 1000 population	33.1	3.9	81.7
Adult literacy rate	47	% of population			
transportation environment					
Paved roads	47	% of total roads	48.2	4.2	100.0
Passenger cars	47	per 1000 population	108.0	1.0	514.7
Pump price for gasoline	47	US\$ /liter	1.3	0.2	2.54
Urban population	47	% of total population	54.9	17.3	92.6
Health Behavior					
western diet	47		0.5	0.04	0.9
Alcohol	47	Total per capita consumption	7.0	0.05	23.01
smoking male	46		35.7	8.0	61.0
smoking female	43		11.1	1.0	36.0
Health governance of the government					
Health expenditure	47	% of total government expenditure	10.9	3.6	28.0

Table 4: Beta coefficients of linear regression analysis for male, female CVD risk factor prevalence and each independent variable across 47 low-middle-income countries

Indicator	Obesity		Insufficient activity		Systolic blood pressure		Blood glucose	
	Male	Female	Male	Female	Male	Female	Male	Female
Economic								
GDP	-2.210	-1.832	-4.122	-4.579	-0.401	-1.235	-0.023	0.036
Unemployment male	0.113	—	0.500	—	0.191**	—	0.001	—
Unemployment female	—	0.309**	—	0.861*	—	0.142*	—	0.006
Education								
School enrollment, tertiary	-0.008	-0.020	-0.055	-0.070	0.016	0.008	-0.007	-0.006
Adult literacy rate	-0.022	-0.080	0.183	-0.210	-0.044	-0.119*	-0.004	-0.011*
Transportation environment								
Paved roads	0.037	0.074**	0.007	-0.028	0.005	0.046**	0.002	0.003
Passenger cars	0.000	-0.028	-0.028	-0.043	0.001	0.000	2.792	0.000
Pump price for gasoline	-1.399	-2.490	4.630	5.451	-0.159	-0.262	-0.091	-0.242*
Urban population	0.144*	0.375**	0.216	0.561*	-0.007	-0.025	0.009*	0.010**
Health behavior								
Western diet	12.220	13.740	22.435	21.740	3.938	-1.675	0.696	0.832*
Alcohol	-0.223	0.135	-1.038	-1.180	0.352**	0.510**	-0.011	-0.007
Smoking male	-0.010	—	-0.396	—	-0.052	—	-0.002	—
Smoking female	—	-0.180	—	0.236	—	0.030	—	-0.005
Health governance of the government								
Health expenditure	0.372	0.331	-1.420	-1.720	-0.116	-0.226	0.005	0.013

** $P < 0.01$ * $P < 0.05$

Nowadays, the developing world still has low education levels and greater gender disparities. The proportion of women with no schooling is consistently higher than that of men (15). For the above reasons, it can be assumed that the adult literacy rate of is a problem related with the risk of CVD in women than in men. Strategies for the prevention of cardiovascular diseases should first let people receive education on health and women need more attention in this regard.

The rate of paved roads had a positive association with obesity and systolic blood pressure, the price of gasoline had a negative

association with blood glucose, and these two indicators were significant among women only. There is growing evidence that the land-use characteristics and transportation patterns affect the levels of physical activity (3) and in this way, they are related to the prevalence of CVD. In the United States, as Frank reported, obesity is associated positively with time spent in cars and negatively with mixed land-use and with walking (16). Our study showed that this effect also exists in low- and middle-income countries.

Women are more vulnerable to the transformation environment than men are. It is probably because of the difference of daily life patterns or of occupational needs and more physical activity among males than among females (3), especially housewives. In our study, among men, the urban population was positively associated with obesity and high blood glucose. Among women, urban population was associated with obesity, low physical activity and high blood glucose. A study reported results similar to our results (17). Mendez reported that, in developing countries, urbanization is associated with profound changes in diet and in exercise that in turn increase the prevalence of obesity (18). Several studies also showed that individuals living in an urban environment have increased cardiovascular risk factors such as, having hypertension, being overweight, and suffering diabetes than did people living in rural areas (19,20). Therefore, in urban areas in low-middle-income countries, more attention should be paid to socioeconomic status and changing lifestyles.

We found that western diet positively associated with blood glucose. As is well known, western diet is unhealthy diet, it is associated with increased diabetes risk and cardiovascular disease (21). With globalization and economic development, increasing urbanization accompanies higher incomes, exposure to mass media, marketing campaigns, and less leisure time which bring out rapid shifts in lifestyle habits and dietary structure of with high intake of processed meats, red meats, and high-fat dairy products in developing-country populations (22). Therefore, we now should pay more attention to the diet pattern and related media campaigns in low- and middle-income countries as well.

Our study also found that alcohol is positively associated with systolic blood pressure. Epidemiological and experimental investigations have established a close association between alcohol consumption and hypertension (23). There is heavy drinking in some localities and groups in the population of many developing countries, and steady rise in alcohol consumption was recorded (24). In order to decrease alcohol consumption in low-

middle-income countries, limitative policy on purchase of alcohol beverages may be needed.

In the health expenditure aspect, no significant relation was found. Research in OECD countries also suggests that there is a weak positive relationship between public spending on health care and premature mortality (25). This research indicated health status attainments are multidimensional concepts that cannot be directly measured by a single set of indicators. Socioeconomic and environmental variables have more influence on health behaviors than government expenditure on health.

In our study, many CVD risk factors are associated with economic factors, education, transportation environment, and health behaviors (such as western diet, alcohol, and smoking) in women more than in men. This means that women are more influenced by these factors than men in low- and middle-income countries are. Our study's results correspond with previous studies in high-income countries as well as in low- and middle-income countries. Many prior studies in high-income countries showed that socioeconomic status and CVD risk accumulation were stronger in women than in men (26, 27). The studies in low-middle-income countries also reported that CVD risk factors have been consistently more strongly associated with socioeconomic status among women than in men (3, 28). Except for socioeconomic status, the reasons for these gender-based differences in CVD risk are unclear although pathophysiological factors, or treatment differences, may play a role (29).

Our conclusions are limited to country-level associations, ignoring variations within a country and individual-level associations. National, objectively measured data of macro-environmental variables in low-middle income countries are largely unavailable, due to which our sample size is small and only has 47 countries. Secondly, we had applied the WHO database from 2008-2009, which is not very new. However, the data from World Bank is relatively recent (until 2011, 2012). The small sample size may cause low reliability and low statistical power. Even though, we emphasize societal rather than individual strategies, and our study focused

on low-middle-income countries, we obtained very useful results that are now required and could be a guideline for future research. We suggest that the effectiveness of intervention program for the prevention of cardiovascular disease in populations in developing countries should be explored. More attention should be given, and health promotion activities should be initiated in low-middle-income countries, especially for women.

Conclusion

The effectiveness of intervention program for the prevention of cardiovascular disease in populations in developing countries should be explored, and more attention should be given to women.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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