

Assessing the Risk of Cardiovascular Disease

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PAPER 1

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Introduction:

Cardiovascular disease (CVD) is a broad term used to describe a range of diseases that involve the heart or blood vessels, including aneurysms, angina, atherosclerosis, congestive heart failure, heart attacks, and peripheral vascular disease. It has been the leading cause of death in the United States for the past 80 years and remains the most common cause of deaths worldwide. It also results in substantial health-care expenditures. Many forms of CVD can be prevented or treated with healthy lifestyle choices. Our project analyzes the many risk factors associated with CVD and predicts the risk level of developing CVD in 10 different patients.

Procedure:

In order to come up with a method for accurately quantifying risk for cardiovascular disease, we began by collecting expert opinions. The following four physicians served as our experts: Michael Scheer, M.D., Daniel Liesen, M.D., Amit Parikh, D.O., and Jose Novoa, M.D. Giving each a list of modifiable and nonmodifiable risks, further divided into 21 separate factors, we asked each to assess the severity of the risk by assigning a weight to each category (see Appendix A for information about the 21 factors). We specified that they assume each particular habit would put the patient among the least healthy 5 percent in each category. For example, for sodium intake, the experts were to assume the particular patient consumed 95% more sodium than all other patients. We gave the following example for them to follow:

- a. Modifiable 70%, Nonmodifiable 30%
- b. Then under Modifiable: Smoking 19%, Stress 5%, Diabetes 10%, Hypertension 15%, Physical Inactivity 7%, Obesity 24%, Diet 6%, Cholesterol 14%
- c. Then under Obesity: BMI 63%, Waist Circumference 37%

After collecting all of our numbers, we tabulated them and created Analytical Hierarchy Process (AHP), Guisus, and Yen equations to calculate risk (see Results for information about the scoring process for the various factors). Taking ten patient files with a wide variety of scores in each category, we were able to apply the equations and determine who faced the highest risk of CVD.

Results:

The AHP, Guisus, and Yen methods combined all four of our expert rankings, and produced an equation that assigned different weights to each of our 21 factors.

The AHP method: In this method, multiply each factor by the average of the expert opinions for that particular factor, as a fraction of the total of all factor averages. Then multiply the number obtained for each factor by the factor variables in the equation (F1, F2,...)

Equation with the two main factors:

AHP G+ equation

$$G+ = 0.7000F1 + 0.3000F2$$

Final equation with all factors:

AHP final F+ equation

$$\begin{aligned} \text{AHPF+} = & 0.1540 F1 + 0.0280 F2 + 0.0840 F3 + 0.1015 F4 + 0.0578 F5 + 0.0526 F6 \\ & + 0.0401 F7 + 0.0480 F8 + 0.0047 F9 + 0.0102 F10 + 0.0384 F11 + 0.0485 F12 \\ & + 0.0321 F13 + 0.1095 F14 + 0.0420 F15 + 0.0443 F16 + 0.0117 F17 + 0.0117F18 \\ & + 0.0143 F19 + 0.0326 F20 + 0.0339 F21 \end{aligned}$$

The Guiasu method: In this method, first normalize one expert's total opinion for each factor. Then average the sum of the experts for each factor. Then multiply the result by each factor variable in the equation.

Equation with the two main factors:

Guiasu G+ equation

$$G+ = 0.7000F1 + 0.3000F2$$

Final equation with all factors:

Guiasu final F+ equation:

$$\begin{aligned} \text{GuiasuF+} = & 0.1540 F1 + 0.0280 F2 + 0.0840 F3 + 0.1015 F4 + 0.0578 F5 + 0.0526 F6 \\ & + 0.0401 F7 + 0.0480 F8 + 0.0047 F9 + 0.0102 F10 + 0.0384 F11 + 0.0485 F12 \\ & + 0.0321 F13 + 0.1095 F14 + 0.0420 F15 + 0.0443 F16 + 0.0117 F17 + 0.0117F18 \\ & + 0.0143 F19 + 0.0326 F20 + 0.0339 F21 \end{aligned}$$

The Yen method: In this method, each expert's opinion is taken as a fraction of the largest element for that particular factor, and then that number for each factor is averaged and that average is divided by the total of all averages for that factor and then

multiplied by the factor variables in the equation.

Equation with the two main factors:

Yen G+ equation

$$G+ = 0.6769F1 + 0.3231F2$$

Final equation with all factors:

Yen final F+ equation

$$\begin{aligned} \text{YenF+} = & 0.1409 F1 + 0.0283 F2 + 0.0832 F3 + 0.0999 F4 + 0.0597 F5 + 0.0496 F6 \\ & + 0.0382 F7 + 0.0477 F8 + 0.0052 F9 + 0.0131 F10 + 0.0348 F11 + 0.0448 F12 \\ & + 0.0314 F13 + 0.1204 F14 + 0.0494 F15 + 0.0509 F16 + 0.0122 F17 + 0.0125F18 \\ & + 0.0148 F19 + 0.0307 F20 + 0.0323 F21 \end{aligned}$$

PREFERENCE RELATIONS

Mu	E1	E2	E3	E4	RowAvg
F1	0.8000	0.8000	0.8000	0.4000	0.7000
F2	0.2000	0.2000	0.2000	0.6000	0.3000
R1	-----				
	0.5000	1.0000			
	0.0000	0.5000			
R2	-----				
	0.5000	1.0000			
	0.0000	0.5000			

R3 -----

0.5000 1.0000

0.0000 0.5000

R4 -----

0.5000 0.3000

0.7000 0.5000

A1 -----

0.0000 1.0000

0.0000 0.0000

A2 -----

0.0000 1.0000

0.0000 0.0000

A3 -----

0.0000 1.0000

0.0000 0.0000

A4 -----

0.0000 0.0000

1.0000 0.0000

Matrix R -----

0.0000 0.7500

0.2500 0.0000

Matrix G -----

0.0000 1.0000

0.0000 0.0000

gList: The mean degree to which g1 is preferred to all other g2, and the opposite

g1 = 1.0000

g2 = 0.0000

gList: The degree to which g1 is preferred to g2; The degree to which g2 is preferred to g1; Q denotes "most"

$zQ(g1) = 1.0000$

$zQ(g2) = 0.0000$

Matrix I(S): Indifference relation; x and y are indifferent

0.0000 0.2500

0.2500 0.0000

Matrix R(S): Incompatibility relation; x and y are not compatible

1.0000 0.2500

0.2500 1.0000

Matrix >(S): Preference relation; x is preferred to y

0.0000 0.7500

0.2500 0.0000

Matrix $\sim(S)$: Non-preference relation; cannot discriminate between x and y

1.0000 0.2500

0.2500 1.0000

Matrix: $V(1, 2)$: Degree of agreement between experts 1 and 2

1.0000 1.0000

1.0000 1.0000

Matrix: $V(1, 3)$: Degree of agreement between experts 1 and 3

1.0000 1.0000

1.0000 1.0000

Matrix: $V(1, 4)$: Degree of agreement between experts 1 and 4

1.0000 0.0000

0.0000 1.0000

Matrix: $V(2, 3)$: Degree of agreement between experts 2 and 3

1.0000 1.0000

1.0000 1.0000

Matrix: $V(2, 4)$: Degree of agreement between experts 2 and 4

1.0000 0.0000

0.0000 1.0000

Matrix: $V(3, 4)$: Degree of agreement between experts 3 and 4

1.0000 0.0000

0.0000 1.0000

Matrix VB: Degree of agreement of all pairs of experts

1.0000 1.0000 0.0000

1.0000 0.0000 0.0000

The degree of agreement of all pair of experts is: 0.5000

Based on these equations, we found rankings for the 10 patients.

Patient Number	AHP Ranking	Guiasu Ranking	Yen Ranking
1	7	7	7
2	2	2	2
3	10	10	10
4	1	1	1
5	9	9	8
6	4	4	4
7	6	6	6
8	5	5	5
9	3	3	3
10	8	8	9

Note: Information on the different patients can be found in Appendix C.

We further analyzed our results using the IBM SPSS Statistics Program. This program used a nonparametric Chi-squared test to determine if we could retain our hypothesis: that all of the R values are the same number. The results show that there are no significant differences among our values; thus, the null hypothesis cannot be rejected.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Experts is the same across categories of R.	Independent-Samples Kruskal-Wallis Test	.343	Retain the null hypothesis.
2	The distribution of Row is the same across categories of R.	Independent-Samples Kruskal-Wallis Test	.112	Retain the null hypothesis.
3	The distribution of Column is the same across categories of R.	Independent-Samples Kruskal-Wallis Test	.112	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Conclusion:

We found these mathematical models to be useful and effective for assessing risk of cardiovascular disease for a spectrum of patients. We believe these methods could be successfully used in future studies. The results and information provided through this study could be used to improve assessments for which patients may be “at risk” for a variety of medical conditions associated with CVD and to create focus groups for those patients. In addition, the different weights for each of the factors can be used to determine which factor contributes most to an increased risk for CVD. This factor can then be targeted accordingly by physicians and other health care workers. Thus, these techniques translate well for application to real world settings. Similarly, these models could help to assess risks of other health concerns as well.

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Appendix A

Risk of Cardiovascular Disease**Modifiable**

- Smoking
 - damages the endothelium (the lining of the blood vessels)
 - increases fatty deposits in the arteries
 - increases clotting
 - raises low-density lipoprotein, reduces high-density lipoprotein
 - Nicotine accelerates the heart rate and raises blood pressure
- Stress
 - causes people to adopt poor habits like smoking and eating badly, which are risk factors for CVD
 - Studies show that acute stress triggers reduced blood flow to the heart
- Diabetes
 - People with diabetes are 2-4 times more likely to develop CVD
 - Uncontrolled diabetes causes damage to your body's blood vessels making them more prone to damage from atherosclerosis and hypertension
- Hypertension
 - stresses your body's blood vessels, causing them to clog or weaken
 - leads to narrowing of the blood vessels making them more likely to block from blood clots or bits of fatty material breaking off from the lining of the blood vessel wall
- Physical Inactivity
 - Being inactive has negative effects on your blood pressure, blood lipid levels, blood glucose levels, blood clotting factors, the health of your blood vessels and inflammation, which are factors of CVD
- Obesity
 - If you are overweight you may develop hypertension, diabetes and atherosclerosis, risk factors of CVD
 - BMI
 - the relationship between your height and your weight
 - >25 is overweight
 - Waist circumference
 - fat, especially intra-abdominal fat, has significant impact on our metabolism
 - This fat affects your blood pressure, your blood lipid levels, and interferes with your ability to use insulin effectively
 - If you cannot use insulin properly you may develop diabetes, a risk factor of CVD
 - Males > 102cm
 - Females > 88cm
- Diet
 - Fats

- abnormal blood lipid levels have a strong correlation with the risk of CVD
- abnormal blood lipids are related to what you eat
- diets high in saturated fats and trans fats leads to high levels of cholesterol
- Alcohol
 - Too much can damage the heart
- Sodium
 - Dietary salt is a significant factor in raising blood pressure
 - >2500 mg/dL
- Cholesterol
 - LDLs
 - High levels of LDL lead to atherosclerosis
 - >130 mg/dL
 - HDLs
 - HDL reduces the risk of CVD as it carries cholesterol away from the blood stream
 - <40 mg/dL
 - Triglycerides
 - most common type of fat in the body
 - High levels of triglyceride combined with high levels of LDL cholesterol speed up atherosclerosis increasing the risk for heart attack and stroke
 - >150

Non-Modifiable

- Age
 - Plaque build up happens over an extended period of time
- Gender
 - Men have a greater risk than a pre-menopausal woman
 - Estrogen protects you from CVD
- Race
 - Asian population has lowest percentage of CVD
 - African Americans have highest percentage of CVD
- Family History
 - Your family's history of CVD indicates your risk

*All information provided by the World Heart Foundation

Appendix B

We collected patient information on the following 21 factors. Based upon the results, the patients were categorized into a group (the left column) for each factor. The point value assigned (the right column) to the specific group is the value that will be incorporated into the determined equations. We came up with each of the categories and their respective values using data from various sources (see resources).

F1: Smoking	
Never Smoked	0
Used to Smoke	.2
0-1 Pack	.4
<1-2 Packs	.6
<2-3 Packs	.8
3+ Packs	1

F2: Stress (Self-Reported Level of Stress)	
Very Low	0
Low	.25
Moderate	.5
High	.75
Very High	1

F3: Diabetes	
No	0
Yes	1

F4: Hypertension (Systolic Pressure)	
<120	0
120-129	.25
130-139	.5
140-159	.75
≥140	1

F5: Physical Inactivity (Minutes of Exercise Per Week)	
>151	0
101-150	.25
51-100	.5
1-50	.75
0	1

F6: Body Mass Index (kg/m²)	
<25	0
25-29	.5
>30	1

F7: Waist Circumference (cm)		
Men	Women	
<80	<70	0
80-99	70-89	.33
100-120	90-109	.66
>120	>110	1

F8: Fat (Saturated and Trans as a percentage of total calories)	
≤10%	0
11-20%	.33
21-30%	.66
>30%	1

F9: Alcohol (number of drinks per day)		
Men	Women	
0-2	0-1	0
3-6	2-4	.5
>6	>5	1

F10: Sodium (mg)	
0-2500	0
2501-3000	.25
3001-3500	.5
3501-4000	.75
>4000	1

F11: HDL (mg/dL)	
>60	0
50-59	.25
45-49	.5
35-44	.75
<35	1

F12: LDL (mg/dL)	
<100	0
100-129	.25
130-159	.5
160-190	.75
>190	1

F13: Triglycerides (mg/dL)	
<150	0
150-199	.33
200-499	.66
≥500	1

F14: Age (years)	
Under 40	0
40-49	.25
50-59	.5
60-69	.75
≥70	1

F15: Gender	
Pre-Menopausal Female	0
Post-Menopausal Female	1
Male	1

F16: Race	
African	1
Asian	1
Any other race	0

F17: Family History of Type-II Diabetes	
No	0
Yes	1

F18: Family History of High Cholesterol	
No	0
Yes	1

F19: Family History of Hypertension	
No	0
Yes	1

F20: Family History of Heart Disease	
No	0
Yes	1

F21: Family History of Heart Attacks	
No	0
Yes	1

Appendix C

Patient 1	
Gender:male	1
Age:41	0.25
Race:Caucasian	0
Diabetes:no	0
Smoking:2 packs/day	0.6
Alcohol:6/day	0.5
Stress Level:high	0.75
Physical Inactivity:60 min/week	0.5
Hypertension:119	0
BMI:32	1
Waist Circumference:83 cm	0.33
Fat %: 7	0
Sodium Intake:2560	0.25
HDL:62	0
LDL:120	0.25
Triglycerides:143	0
Family History:yes	1
Patient 2	
Gender:female	0
Age:79	1
Race:African American	1
Diabetes:yes	1
Smoking:2 packs/day	0.6
Alcohol:no	0
Stress Level:low	0.25
Physical Inactivity:0 min/week	1
Hypertension:120	0.25
BMI:20	0
Waist Circumference:58cm	0
Fat %:7	0
Sodium Intake:2500	0.25
HDL:55	0.25
LDL:130	0.5
Triglycerides:153	0.33
Family History:no	0
Patient 3	
Gender:male	1
Age:64	0.75

Race: Hispanic	0
Diabetes:no	0
Smoking:no	0
Alcohol:no	0
Stress Level:very low	0
Physical Inactivity:140min/week	0.25
Hypertension:115	0
BMI:25	0.5
Waist Circumference:78	0
Fat %:8	0
Sodium Intake:2800	0.25
HDL:61	0
LDL:102	0.25
Triglycerides:155	0.33
Family History:yes	1
Patient 4	
Gender:female	0
Age:42	0.25
Race:African American	1
Diabetes:yes	1
Smoking:3packs/day	0.8
Alcohol:2/day	0.5
Stress Level:high	0.75
Physical Inactivity:0	1
Hypertension:135	0.5
BMI:31	1
Waist Circumference:93	0.66
Fat %:18	0.33
Sodium Intake:3560	0.75
HDL:36	0.75
LDL:191	1
Triglycerides:204	0.66
Family History:no	0
Patient 5	
Gender:male	1
Age:18	0
Race:Asian	1
Diabetes:no	0
Smoking:no	0
Alcohol:7/day	1

Stress Level:moderate	0.5
Physical Inactivity:112min/week	0.25
Hypertension:120	0.25
BMI:28	0.5
Waist Circumference:78	0
Fat %:15	0.33
Sodium Intake:3900	0.75
HDL:46	0.5
LDL:103	0.25
Triglycerides:148	0
Family History:yes	1
Patient 6	
Gender:female	0
Age:103	1
Race:Pacific Islander	1
Diabetes:yes	1
Smoking:no	0
Alcohol:no	0
Stress Level:very low	0
Physical Inactivity:0	1
Hypertension:118	0
BMI:21	0
Waist Circumference:55	0
Fat %:5	0
Sodium Intake:1700	0
HDL:53	0.25
LDL:95	0
Triglycerides:140	0
Family History:no	0
Patient 7	
Gender:female	0
Age:33	0
Race:Hispanic	0
Diabetes:yes	1
Smoking:1pack/day	0.4
Alcohol:1/day	0
Stress Level:high	0.75
Physical Inactivity:170min/week	0
Hypertension:120	0.25
BMI:26	0.5

Waist Circumference:71	0.33
Fat %:12	0.33
Sodium Intake:2600	0.25
HDL:52	0.25
LDL:128	0.25
Triglycerides:160	0.33
Family History:yes	1
Patient 8	
Gender:male	1
Age:96	1
Race:Caucasian	0
Diabetes:no	0
Smoking:used to smoke	0.2
Alcohol:no	0
Stress Level:low	0.25
Physical Inactivity:45min/week	0.75
Hypertension:125	0.25
BMI:24	0
Waist Circumference:82	0.33
Fat %:11	0.33
Sodium Intake:2400	0
HDL:58	0.25
LDL:131	0.5
Triglycerides:160	0.33
Family History:no	0
Patient 9	
Gender:male	1
Age:25	0
Race:African American	1
Diabetes:yes	1
Smoking:no	0
Alcohol:no	0
Stress Level:moderate	0.5
Physical Inactivity:170min/week	0
Hypertension:115	0
BMI:24	0
Waist Circumference:75	0
Fat %:23	0.66
Sodium Intake:3900	0.75
HDL:46	0.5

LDL:183	0.75
Triglycerides:204	0.66
Family History:yes	1
Patient 10	
Gender:female	0
Age:53	0.5
Race:Pakistani	0
Diabetes:no	0
Smoking:no	0
Alcohol:no	0
Stress Level:high	0.75
Physical Inactivity:140min/week	0.25
Hypertension:140	0.75
BMI:27	0.5
Waist Circumference:78	0.33
Fat %:5	0
Sodium Intake:2400	0
HDL:36	0.75
LDL:185	0.75
Triglycerides:280	0.66
Family History:yes	1

Appendix D

Risk of Cardiovascular Disease		
Modifiable	F1 Smoking	
	F2 Stress	
	F3 Diabetes	
	F4 Hypertension	
	F5 Physical Inactivity	
	Obesity	F6 BMI F7 Waist Circumference
	Diet	F8 Fat (Saturated and Trans) F9 Alcohol F10 Sodium
	Cholesterol	F11 HDLs F12 LDLs F13 Triglycerides
Non-Modifiable	F14 Age	
	F15 Gender	
	F16 Race	
	Family History	F17 Type-II Diabetes F18 High Cholesterol F19 Hypertension F20 Heart Disease F21 Heart Attacks