Determining Treatment Cost to Reduce CVD Risk with Dynamic Programming

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***Abstract*—Dynamic Programming is an algorithmic strategy to solve problems with finite possible solution. Dynamic Programming is used to get the most optimum solution of a problem. In this paper, Dynamic Programming is used to deciding the most efficient treatment to reduce the chance of developing Cardiovascular Diseases (CVDs), a group of diseases which involves heart and blood vessels, which is dependent to the patient's risk factors. These risk factors ranges from age and lifestyle to genenetics and other diseases .**

***Index Terms*—CVD, Dynamic Programming, CVD Treatment Cost, Reducing CVD SCORE.**

I. Introduction

Cardiovascular Diseases (CVDs) are one of the most dangerous diseases on earth. CVDs are the leading cause of death. Around 17.5 million deaths are caused by CVDs in 2012, which is 31% of global death. They can also cause prolonged disability, which impairs productivity and, thus, economy.

CVDs are diseases which involves heart and blood vessel. There are many types of CVD, they're coronary heart disease, cerebrovascular disease, peripheral arterial disease, rheumatic heart disease, congenital heart disease, deep vein thrombosis and pulmonary embolism, but the most common CVDs are heart attack and stroke.

The risks of CVDs are affected by many factors. The risk factors for CVDs are blood pressure, cholesterol, diabetes, physical activity, body weight, genetics, and age:

1. The blood pressure compared, in this case, is the systolic pressure. The higher above normal the blood pressure is, the risk of CVD also increases. High blood pressure could damage artery walls and could also cause blood clot.
2. The blood cholesterol affects the same way as blood pressure. Higher blood cholesterol level means greater chance of CVD.
3. Smoking also increases the chance of CVD. People who smoke have the risk of CVD twice the people who doesn't.
4. Diabetes affects CVD because damages caused by diabetes are similar to the ones that are caused by hypertension.
5. People with obesity are more likely to develop diabetes and hipertention, therefore, higher chance of CVD.
6. Low physical activity would encourage the other risk factors to increase. People who don't exercise regularly would be more likely to have higher blood pressure and cholesterol level.
7. People whose family has history of CVD are more likely to develop CVD. Certain ethnic backgrounds also affect the chance to develop CVD.
8. Older person have higher chance to develop CVD.

Other than those factors mentioned above, unhealthy diet also affects the risk of CVD. Harmful use of alcohol and tobacco could increase the chances to develop CVD. Lack of fruit and vegetable consumption and also over consumption of salt could lead to CVD.

As mentioned above, CVDs are dangerous diseases. Complications caused by CVD are mostly severe. For example, there are stroke complications:

- Stroke could cause swelling of the brain and this can cause death. This swell is caused by increased pressure on the brain on a person who had hemmoragic stroke.
- Fever makes the chance of recovery worse especially if it occurs at the same time as the stroke. Fever usually caused by an infection. High blood sugar (glucose). This often occurs in people who have diabetes. Very high or low blood sugar immediately after a stroke interferes with proper brain cell function, increasing the risk of damage.
- The body attempt to increase blood flow may cause changes in blood pressure. This usually occurs several days after the stroke occurs. If this leads to a sudden drop in blood pressure, the brain could even be more damaged.
- Hydrocephalus could occur especially to hemmoragic stroke victims.

And many other complications including seizures, another stroke, or even comma.

Another example are heart failure complications:

- Atrial fibrillation, which could make heart failure worse and even could lead to stroke.
- Ventricular fibrillation or tachycardia, which could cause fainting and sudden death.
- Kidney failure, causing less urine, fatigue, and could also cause death.
- Anemia, also cause fatigue.
- Heart valve condition, could also worsen heart failure and may need surgery to recover.
- Cardiac cachexia, which is life-threatening.

And many others, including stroke.

In this article, I will give an example on how to decide the most efficient treatment to be taken by implementing dynamic programming. In this example, the situation is simulated in Indonesia, different conditions may be applied in different countries.

II. CVD SCORE CHART

CVD SCORE Chart is one way to measure one's risk of getting CVD in the next 10 years. The chart is divided for two different types of country: High Risk Countries and Low Risk Countries. This chart can be used to decide what to do to lower the SCORE.

According to recent data [6], Indonesia is classified as Low Risk Country with around 150 death rate caused by CVD.

This chart is divided into four groups, non-smoker women, smoker women, non-smoker men, and smoker men. The SCORE itself represents the risk of developing CVD of a person in the next 10 years. It could be easily observed that men have higher SCORE than women and smokers have roughly twice the SCORE of non-smoker.

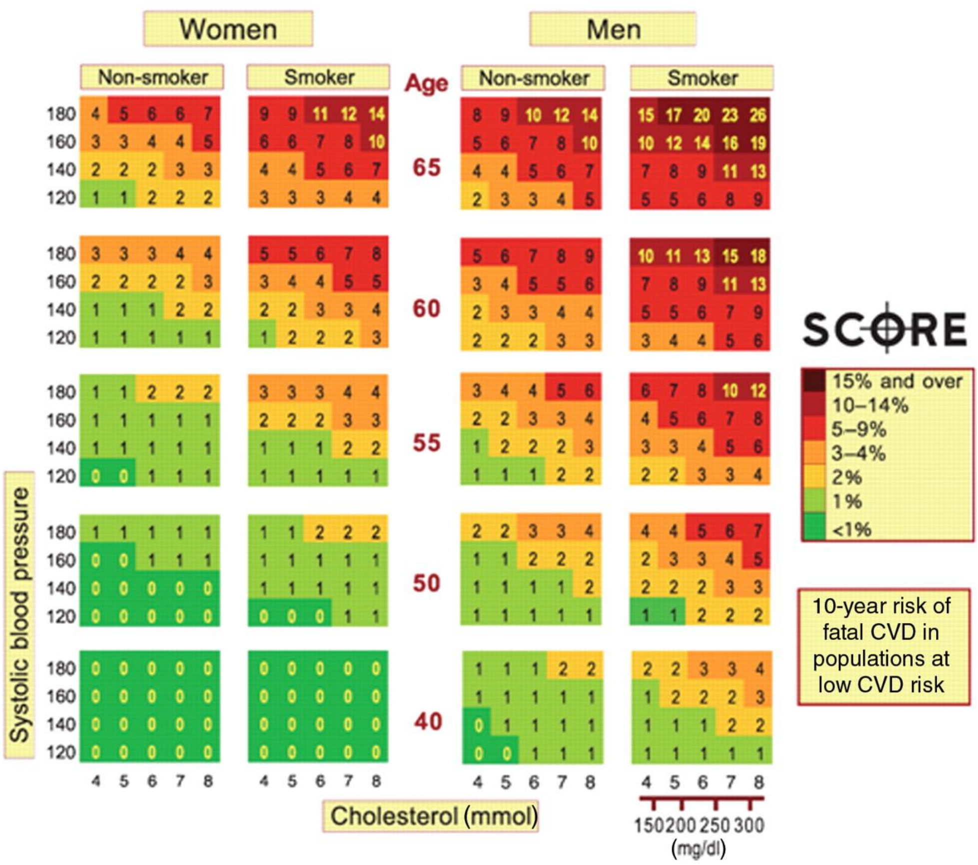
This chart is made to roughly assess the risk of a seemingly healthy person with no symptoms of these diseases. This chart can also be used to plan our life to avoid these diseases by setting goals to reduce our SCORE.

In this chart, factors that affect the chance to develop CVD are blood pressure, cholesterol concentration, age, gender, and smoking habit. Higher blood pressure and cholesterol level means higher SCORE. Older person also have significantly higher score than younger ones.

From this chart, we could learn what to treat to reduce our SCORE according to our current condition. We should aim to have normal systolic blood pressure, which is around 120mmHg, and normal cholesterol level, which is 4. Smokers should also consider to stop smoking after seeing this chart.

The colors in this chart represent the severity of the

Fig. 1 SCORE Charts for Low Risk Countries [3]



risk. The green SCOREs are considered safe levels, so people shouldn't worry much if they're in the green area. This is the area that should be aimed by every person. People with yellow and orange SCOREs are advised to take medicine to treat their condition. People in this area are considered 'okay', but it's still better if they could reach the green area. Finally the red colors, this indicates that a person needs medical treatment immediately to prevent CVD. People in this area are strongly advised to control their lifestyle so that they could reach the safer areas.

III. Dynamic Programming

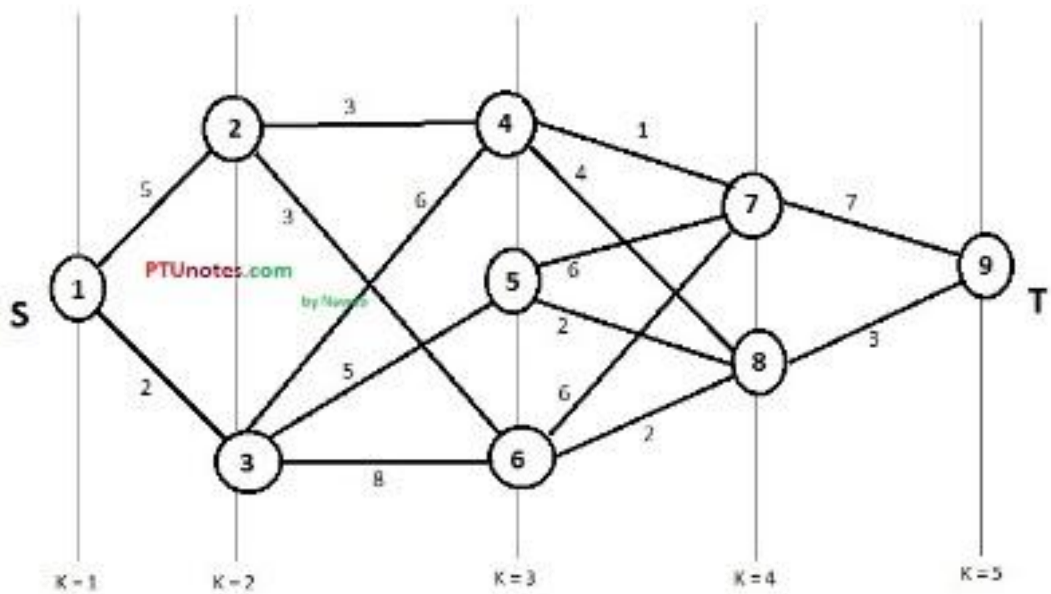
Dynamic Programming (DP) is a technique to find the most optimum solution of a problem. DP divides the solution into several steps which creates sub-solutions. Each step transitions cost are counted to be considered as final sub-solution. These sub-solutions are then combined into a complete and optimum solution.

In DP, we represent the choices available in each steps with nodes. These nodes are linked to all the nodes in the next step and also the previous steps. The vertices represent the cost of proceeding to the next step. This graph will provide all possible solutions of the problem.

Each value of vertices are counted separately, they're independent of each other. These values represent sub-solutions of those steps. To count the total cost to reach the nth step

DP can be used when the combination of sub-solutions are finite. We need these combinations to be finite so that we could get the optimum solution to our problem. If the combinations are infinite, the algorithm will endlessly check for a more optimum solution. While we can force the algorithm to stop after a reasonable amount of iterations, it won't guarantee the solution it offers is optimum.

Fig. 2 Dynamic Programming Graph Example [2]



Pseudocode (cited from [2]):

```
Set Min[i] equal to Infinity for all of i
Min[0]=0

For i = 1 to S
For j = 0 to N - 1
  If (Vj<=i AND Min[i-Vj]+1<Min[i])
Then Min[i]=Min[i-Vj]+1

Output Min[S]
```

IV. Choosing the Most Effective Treatment

It is natural for living beings to desire a long, healthy life. By reducing our SCORE, we'd have better chance to avoid CVD in the next ten years. One of the ways to reduce our SCORE is by receiving medical treatments, but there's a catch, we may not be able to afford all of the treatments. So, the alternative is to get the most efficient and affordable treatments.

For example, we have an individual with sex S, age A, blood pressure P, Sm to identify smoker, cholesterol concentration Cc, with budget B. The hospital provides blood pressure treatment for BT, cholesterol treatment for CT, and smoking therapy for ST. The chart SCORE is represented with CH(S,A,P,Sm,Cc).

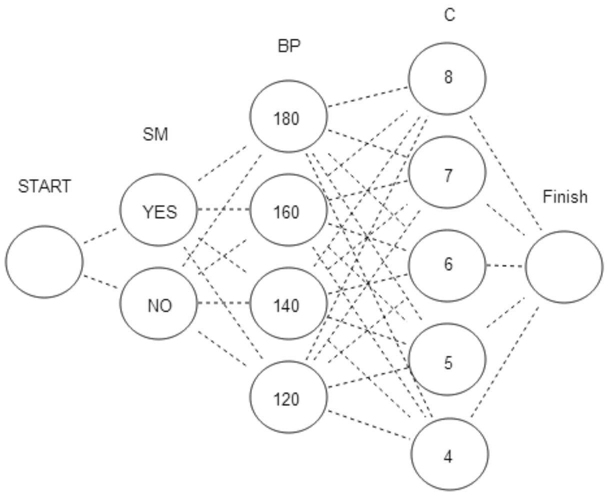
To make our blood pressure normal, we need roughly one kind of medicine each 20pp, while for cholesterol we only need one medicine for any level.

We obviously cannot change our age nor our gender, so we have a graph with five steps: start, SM, BP, C, and finish. We assign each treatment cost to the vertex that point to the corresponding treatment and also the SCORE reduction as the result of the treatment. We also add vertices with zero cost for not taking the treatment and vertices with infinite cost for unreachable states. Unreachable states are states with values higher than the current value.

- The value of start to SM(yes) = ST and $CH(S, A, P, yes, Cc) - CH(S, A, P, no, Cc)$.
- The value of SM to BP(n) = $n)\ div\ 20) * BT$ and $CH(S, A, P, Sm, Cc) - CH(S, A, n, Sm, Cc)$.

The value of BP to C(n) = $CT\ and\ CH(S, A, P, Sm, Cc) - CH(S, A, P, Sm, n)$.

Fig. 3 Choosing Treatments to Prevent CVD



Choosing the right treatments:

1. Count the values of every state transition.
2. Take the most SCORE reduction step.
3. If the total cost is higher than B, take the next highest SCORE reduction step.
4. Repeat step 3 until the total cost is equal or lower than B.
5. Repeat step 2 with different step to begin with.
6. Choose the highest SCORE reduction path.

Table 1. First Step values

	Cost	Reduction
SM(yes)	ST	$CH(S, A, P, yes, Cc) - CH(S, A, P, no, Cc)$
SM(no)	0	0

Table 2. Second Step Values

	Cost	Reduction
BP(180)	$((P - 180)\ div\ 20) * BT$	$CH(S, A, P, Sm, Cc) - CH(S, A, 180, Sm, Cc)$
BP(160)	$((P - 160)\ div\ 20) * BT$	$CH(S, A, P, Sm, Cc) - CH(S, A, 160, Sm, Cc)$
BP(140)	$((P - 140)\ div\ 20) * BT$	$CH(S, A, P, Sm, Cc) - CH(S, A, 140, Sm, Cc)$
BP(120)	$((P - 120)\ div\ 20) * BT$	$CH(S, A, P, Sm, Cc) - CH(S, A, 120, Sm, Cc)$

Table 3. Third Step Values

C(8)	CT	$CH(S, A, P, Sm, Cc) - CH(S, A, P, Sm, 8)$
C(7)	CT	$CH(S, A, P, Sm, Cc) - CH(S, A, P, Sm, 7)$
C(6)	CT	$CH(S, A, P, Sm, Cc) - CH(S, A, P, Sm, 6)$
C(5)	CT	$CH(S, A, P, Sm, Cc) - CH(S, A, P, Sm, 5)$
C(4)	CT	$CH(S, A, P, Sm, Cc) - CH(S, A, P, Sm, 4)$

The values of attributes other than the attribute changed in the current step are taken from the original attributes. This is applied to make the calculation simpler and also the changed attribute are the most significant reduction factor. Even though, better implementation could lead to a more accurate result. The total reduction is calculated by counting the difference between the charts's SCORE of the original attributes and the SCORE of the new attributes after the treatments.

V. Conclusion

CVDs are very devastating diseases, but preventable. It is important for every individuals to realize the risks of developing CVD in their current condition. By choosing a healthy and active lifestyle, we could greatly reduce the risk to develop CVD. Although it is preventable by changing our lifestyle, medical treatment(s) are required when our SCORE reaches certain degrees.

Dynamic programming is one of the solutions that could lead to the most effective treatments. Although the factors that could lead to CVD are not complete in this article, it could give the big picture on how to decide the treatments to be taken considering the factors that could affect our chances to get CVD.

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STATEMENT

I hereby declare that I wrote this paper are my own writing, not adaptation, or translation of papers of others, and not plagiarism .

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