Cholesterol Tracker

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Abstract

One of the leading causes of death in the United States is heart disease [1]. The most common type of heart disease is coronary artery disease [1]. High cholesterol is associated with a higher risk in cardiovascular disease [2]. Therefore, being able to keep track of cholesterol is important if a person is at risk for high cholesterol. Healthy adults usually get their cholesterol checked every four to six years, but those who have heart disease, diabetes, or a family history of high cholesterol, have to get their cholesterol checked more frequently [3]. Additionally, it is recommended for older adults to receive annual cholesterol tests. This means that patients at risk of high cholesterol will have to visit the doctor's rather often to make sure their cholesterol levels are not too high. Moreover, checking cholesterol regularly will keep a person at risk of high cholesterol from plaque buildup in their arteries, which could lead to heart disease or stroke [1]. This project utilizes two MATLAB GUI's where the user would input their own data and it keeps track of patients' cholesterol test information and analyzes this information to return if their levels are normal, borderline high, or high, provide recommendations according to those levels, and a 10-year risk assessment for a hard coronary heart disease. It also allows a patient to determine if their cholesterol levels are risky in the comfort of their own home.

1 Introduction

Cardiovascular diseases (CVDs) are the leading cause of global mortality and a major contributor to disability. Cases of CVD nearly doubled from 271 million cases in 1990 to 523 million cases in 2019. The prevalence and incidence of CVD is particularly high in high-income countries like the United States [4]. Heart disease is the leading cause of death for women and men of various racial and ethnic groups across the United States of America. It is estimated that one person dies every 34 seconds from cardiovascular disease [5]. Core behaviors such as smoking, physical activity and diet in addition to health factors such as cholesterol, blood pressures and glucose control are key contributors to cardiovascular health [6].

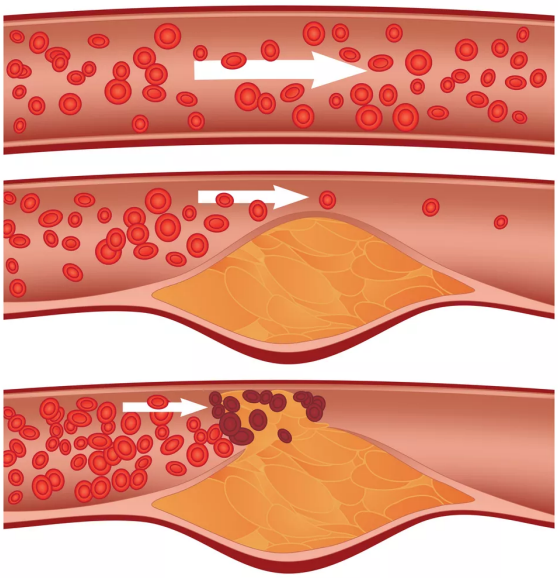

Figure 1 Atherosclerosis. Top artery is healthy. Middle and bottom arteries show plaque formation. Bottom artery shows rupturing, clotting and blood flow occlusion [7].

Cholesterol is a fat-like substance that can build up in arteries and settle as plaque [8]. Cholesterol travels through the blood on proteins called lipoproteins. The two types of lipoproteins

are low-density lipoprotein cholesterol (LDL). High levels of LDL cholesterol increase a person's risk of CVD and stroke. The second type of cholesterol is high-density lipoprotein cholesterol (HDL). High levels of HDL can lower a person's risk of CVD and stroke. HDL absorbs cholesterol in the blood and carries it to the liver where the excess cholesterol is disposed [9].

High cholesterol, in particular, is known as a silent killer since it can easily go undetected. The CDC reported that more than 102 million Americans (20+) have high total cholesterol levels, anything above 200 mg/dL. Given these conditions, the only way to know whether a person has high cholesterol is to get their cholesterol checked through a lipid profile. Healthy adults are recommended to get theirs checked every 4 to 6 years. People with a history of heart disease, disease, or a tendency of high cholesterol need their cholesterol checked more often [10].

Current solutions in the market that address this need include the creation of an interactive website by the Bayer Corporation. Some of the features include health management tools for calculating their risk of having a heart attack, providing dietary recommendations, and tracking users' progress to meeting their cholesterol goals [11]. Another solution is an application available for Androids and iPhones called Cholesterol Food Reference which provides cholesterol values of everyday foods. MyFitness Pal is an application available for Androids and iPhones that recommends healthy eating habits and exercise to lower cholesterol levels. Smart Blood Pressure is an application available for iPhones which tracks blood pressure, locates patterns, and logs dietary cholesterol and medications being taken [12].

Given the burden of disease of CVDs, there is a widespread need for people in the United States to be conscious about their cardiovascular health. Though there are various fitness and dietary applications in the market, it is necessary to have an application that focuses on cholesterol tracking and provides an additional layer of care for the user. Tracking their cholesterol over time, understanding the implications of the numbers produced by their lipid profile, and having resources to maintain or improve their cholesterol levels are key to the user's health and quality of life. Our primary users are 30-78-year-old people who are interested in keeping records of their cholesterol levels and want to know their risk of CVDs as well as resources on how to prevent them. A successful application would expand a growing field in medicine. Applications such as Cholesterol Tracker will encourage users to recognize their role in disease progression and empower them in their decision-making by providing them a centralized location of their cardiovascular health status.

2 Dataset

No data sets were used in this project. All data is generated by the user.

3 Methods and Implementation

The software used in this project was MATLAB and MATLAB App Designer. No external software was used, except for an md5 algorithm function that encrypts user passwords [13]. The design consists of two GUIs and three functions, a summary is shown in Figure 2.

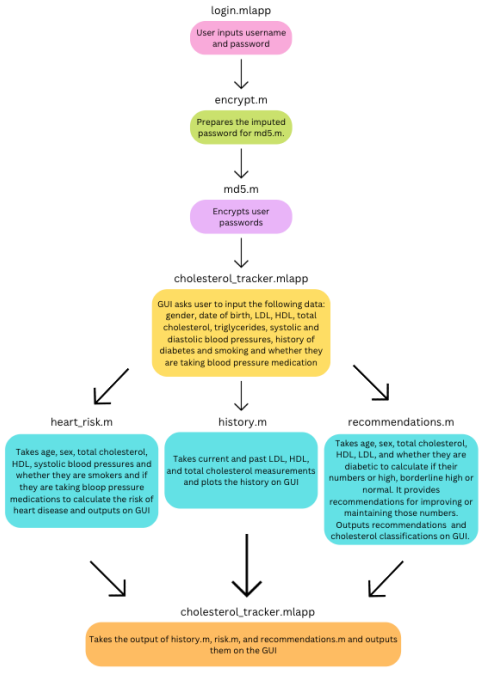

Figure 2. Graphical representation of Cholesterol Tracker. References login.mlapp, encrypt.m, md5.m, cholesterol_tracker.mlapp, heart_risk.m, history.m, and recommendation.m to reference the sequence of GUIs and functions that interact to produce the output.

The project contains two GUIs. One GUI, login.mlapp, where the user inputs their username and password which is shown in Figure 3. If the user is new, it will add their username and an encrypted form of their password to a database if the username is not already taken. If the username is taken, an error message is displayed. Once the new user is successfully created they will go to the next GUI, cholesterol_tracker. For an existing user, they must input the correct combination of username and password to move to the next GUI. Otherwise, an error message is displayed.

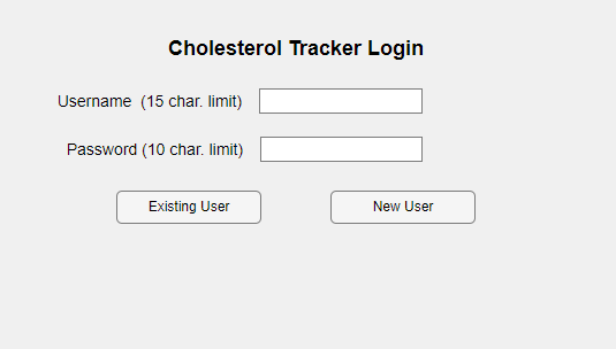

Figure 3. login.mlapp. The GUI screen for login.mlapp. It takes in the user's username and password. If they click the new user button the username will be inputted into a SQL database if the username is unique and if not an error message will be displayed. If they are an existing user it will be cross-referenced against the table. If their username and password are correct they will go to the next GUI and if not it will provide an error message.

Two functions were used in conjunction with the login.mlapp GUI, encrypt.m and md5.m. As stated before md5.m was used to apply the md5 algorithm, while encrypt.m was used to prepare the imputed password for md5.m.

The second GUI takes in the user's gender, date of birth, LDL, HDL, total cholesterol, triglycerides, systolic blood pressure, diastolic blood pressure, if they have diabetes, if they smoke, and if they are taking medication for blood pressure, shown in Figure 4. Once all of that data is submitted, it graphs their cholesterol history, outputs if their levels are normal, high, or borderline high, provides recommendations based on those levels, and provides a 10 year risk assessment for hard coronary heart disease based off of an online calculator [14].

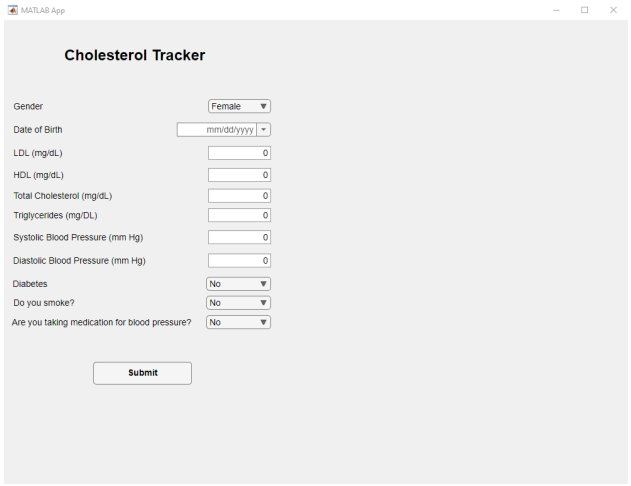

Figure 4. cholesterol_tracker.mlapp. The GUI screen for cholesterol_tracker.mlapp. It takes in the user's cholesterol data, blood pressure, if they have diabetes, if they smoke, and if they are taking medication for blood pressure. The right side of the screen is currently empty, but once the submit button is clicked a graph appears that shows a graph of previous cholesterol history. If their cholesterol numbers are high, borderline high, or normal, a 10-year risk for developing coronary heart disease, and links to recommendations.

Three functions were used in conjunction with the cholesterol_tracker.mlapp GUI. History.m was used to input the new cholesterol user data into a SQL database as well as retrieve the last ten user inputs so that it can be graphed. Heart_risk.m was used to calculate the 10-year risk for developing hard coronary heart disease based on the latest user inputs. Finally, recommendations.m was used to compare inputted cholesterol data against accepted standards and return if LDL, HDL, or total cholesterol was high, borderline high, or normal.

Based on those results, links to websites were provided to help the user and provide feedback.

The database, userinfo.db, is composed of two tables. The first table is called users and has three fields: a unique primary id, the inputted username, and inputted password.

	id	username	password
	Filter	Filter	Filter
1	1	Gerald82	025074e89ec953ab33d8765cb61149e0
2	2	jessbaggett	bab1f8247d2a509fea2c9d9b22136c4d
3	3	Em727	d845de62814b83d6ba945f084f2e40c0
4	4	Cynthia4	651f0802ae70fa364b1b372ff8cc7e3c
5	5	Harold!	d2b2ed857a7f4d51f574a217836ab982

Table 1. Users Table Database Schema. The table shows the schema for the user table. There are three fields: id, username, and password. The password field shows the md5 algorithm encrypted password.

The second table, data, has seven fields: id, username, total_chol, LDL, HDL, Triglycerides, and input_date. The usernames can be repeated as this is where all of the data from the second GUI, cholesterol_tracker.mlapp is kept and. The usernames are so the data can later be called back.

	id	username	total_chol	LDL	HDL	Triglycerides	input_date
	Filter	Filter	Filter	Filter	Filter	Filter	Filter
1	1	Gerald82	180	110	35	135	2020-08-25
2	2	Gerald82	192	114	38	131	2020-12-13
3	3	Gerald82	179	108	42	129	2021-06-7
4	5	Gerald82	165	92	51	125	2022-03-18
5	6	Gerald82	172	99	47	128	2021-11-15
6	7	Gerald82	165	92	49	130	2022-10-30
7	8	Em727	150	77	65	122	2021-07-16
8	9	Em727	155	77	69	118	2022-04-2
9	10	Cynthia4	178	88	54	136	2022-02-14
10	11	Gerald82	163	88	51	128	2022-12-06

Table 2. Cholesterol Data Table Database Schema. The table shows the schema for the data table. There are seven fields: id, username, and password. username, total_chol, LDL, HDL, Triglycerides, and input_date.

To verify that the login.mlapp was correctly established, a unique username and password were generated. Then, incorrect combinations of the username and password were entered to verify that an error message appeared. It was also tested to make sure that no duplicate usernames could exist by trying to create a new user that had the same username as a previous user. An error message is expected to appear on the GUI. To test that the heart_risk.m function was correctly established 5 different trials were run comparing the output of heart_risk.m and an online calculator [14]. The test is only successful if all outputs from the function match the online calculator. To test if recommendations.m worked 12 different trials were run comparing the output of recommendations.m to a chart that contains healthy cholesterol levels [15]. The test is only successful if all outputs from the function match the expected results provided by the tables.

4 Experiments and Results

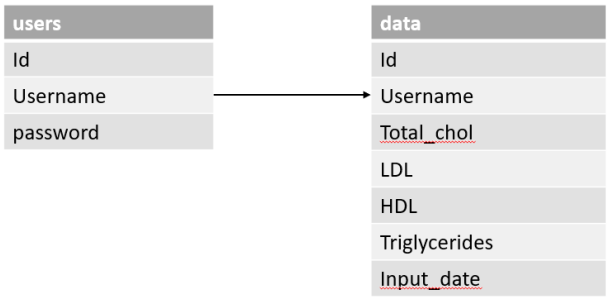

Figure 5 userinfo.db ER diagram. userinfo.db has two tables: users and data. Only the username is passed from the users table to the data table, no other info is passed.

Fictional data sets were entered into the GUI's and the outputs for the risk of hard coronary heart disease and cholesterol levels were compared against the expected results.

The GUI login.mlapp passed its test. When inputting an incorrect password or username an error message was shown. Also when a new user tried to input a username that was already taken an error message was shown.

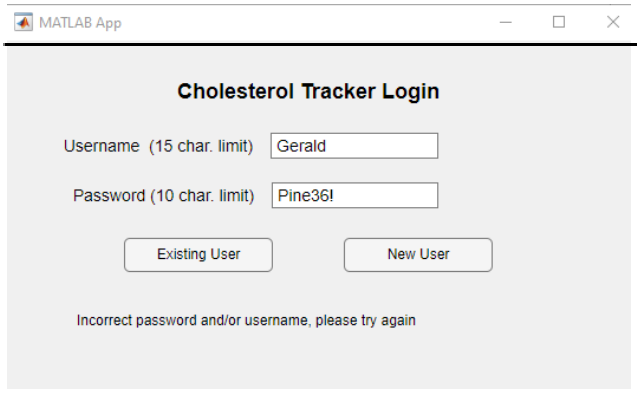

Figure 6. login.mlapp error message. The GUI screen for login.mlapp when an incorrect combination of username and password is imputed. The correct combination of username and password should have been Gerald82 and Pine36!.

The function heart_risk.m also passed all five of its trials. The expected results provided by the online calculator matched the experimental results provided by the function.

Age	Gender	Smoker	Total Cholesterol	HDL	Systolic BP	Meds	Expected	Actual
62	male	yes	210	31	140	no	23.8%	23.77%
30	female	no	152	63	106	no	0.0%	0.01%
54	female	yes	185	52	125	yes	3.9%	3.93%
48	male	no	167	54	111	no	1.9%	1.86%
75	female	no	192	48	118	yes	7.1%	7.09%

Table 2. Comparing results of heart_risk.m. The table shows the expected and actual results of heart_risk.m. The expected results come from an online calculator. The other columns represent the data that was imputed.

The recommendations.m function was tested with twelve unique test cases varying from age, gender, total cholesterol, LDL, HDL, and whether they had diabetes. The function successfully filtered through age and gender to identify whether cholesterol levels were high, borderline high, or normal. Results from the function were cross-referenced with Cleveland Clinic's cholesterol classification of high, borderline high, and normal cholesterol [15]. In addition, the function successfully provided recommendations on diet and exercise based on whether the user indicated they had diabetes. Recommendations were retrieved from a variety of sources including Harvard Medical School, Mayo Clinic, Hopkins Medicine, and the CDC among others to provide a variety of reading material.

Age	Gender	Total Cholesterol	LDL	HDL	Diabetes
10	male	200	140	30	yes
15	female	199	129	45	no
19	male	160	100	50	yes
20	male	280	180	59	no
20	male	250	170	40	yes
30	male	240	160	35	no
30	female	239	159	59	yes
40	female	220	135	40	no
40	female	200	100	50	yes
50	female	190	99	60	no
50	male	150	90	70	yes
80	male	100	80	80	no

Table 3. Recommendations.m test cases. The table shows the twelve unique test cases. Their total cholesterol, LDL and HDL have been color coded depending on the classification given by Cleveland Clinic. High is red, borderline high is orange, and normal is green.

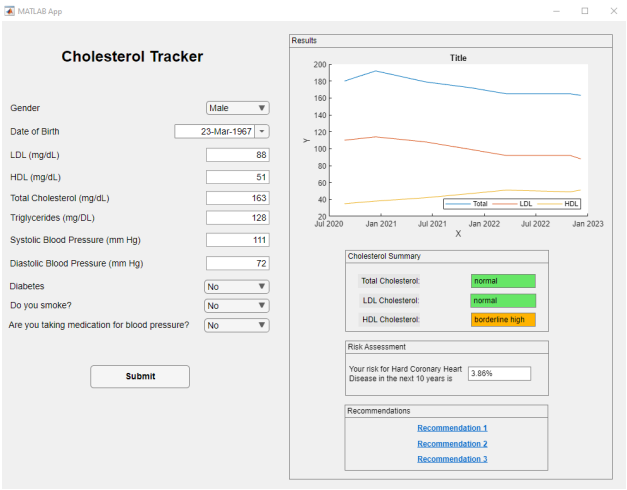

Figure 7 Functional Cholesterol Tracker. Once a user inputs their data and clicks submit, the Cholesterol Tracker GUI will output their history in the form of a graph, it will indicate whether their total cholesterol, LDL and HDL are high, borderline high or normal and will provide recommendations based on their results.

5 Discussion

The primary functions of this project were to analyze the user's inputted cholesterol information and output their level of cholesterol (normal, borderline high, high), and

recommendations corresponding to the level, a plot that contains their recent 10 total cholesterol, LDL and HDL values.

According to the Cleveland Clinic, there are three categories of cholesterol levels. Normal cholesterol consists of a total cholesterol value of under 200 mg/dL, LDL value of under 100 mg/dL, and HDL value of 60 mg/dL and higher. Borderline high cholesterol consists of a total cholesterol value of 200 - 239 mg/dL, LDL value of 100 - 159 mg/dL, and HDL value of 40 - 59 mg/dL for males and 50 - 59 mg/dL for females. The high cholesterol level consists of a total cholesterol value of 240 mg/dL and higher, LDL value of 160 mg/dL and higher, and HDL value under 40 mg/dL for males and under 50 mg/dL for females. The values from Cleveland Clinic are similar to the ones from a book from the NIH [16]. According to this book, a higher risk of cardiovascular disease is associated with low HDL levels, high LDL levels, and high total cholesterol levels, which correlates to the information from Cleveland Clinic.

The current limitations of the project include the inability to backdate information, and to calculate the risk of coronary heart disease for non-diabetic patients younger than 30 or older than 79 years of age who do not have a history of cardiac events. The code automatically uses the date the user inputs their cholesterol test information as the input date, and there is no option to change it to another date. For people who do not consistently input their cholesterol information into the GUI, the input dates would not be accurate. Additionally, the 'hard' coronary Framingham outcomes model is used to calculate the risk of coronary heart disease, so if the patient was diabetic and not between the ages of 30 and 79, the risk calculated would not be reliable. Furthermore, the recommendations are limited to diet and exercise, which means the patient's individual health status is not considered.

A follow-up study that could be performed to improve upon our findings is further research on specific recommendations for different patients with different cholesterol levels to receive. The ones provided in this project are related to diet and exercise, but are general and do not take into account varying health conditions.

There are three features we would like to add to the current project. The first is to make it possible for users to input cholesterol data for past dates and not restrict the input date to the day that they're inputting their information. The next feature would be to create more personalized recommendations for the patients depending on their cholesterol levels. The last feature we would like to add is to include another GUI or page where the user can select past data entries, further than the last 10 entries, in the form of a plot or similar to how it is viewed in SQL.

6 References

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