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PAPER

CoLipid: A Mobile Application for Lipid Monitoring

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ABSTRACT

The recent healthcare transformations emphasize the importance of individuals maintaining a healthy lifestyle through proper nutrition and physical activity to reduce the risk of severe illnesses. Patients often search for information on their own, leading to uncertainty about appropriate diets or fitness activities. Consequently, many individuals cross-check information or health advice from various sources. However, some people hesitate to verify online health-related information with their clinicians, fearing that it may be perceived as a challenge to their expertise and authority. This study aimed to determine a useful way to monitor a patient's lipid profile and provide recommendations for meal plans and fitness activities. A content-based approach that utilizes a vector space model is employed in the development of a recommender method. The vector space model uses meal plan keywords to suggest similar items, and selection rules are applied to identify relevant meal plan and fitness activity options. This approach has been integrated into a mobile application for healthcare, enabling patients to receive personalized recommendations based on their lipid levels. To assess the usability of the mobile application, an initial user study was conducted, which revealed that most respondents had a positive opinion of the application. In the future, the application could be enhanced with a wider variety of meal plans and additional features.

KEYWORDS

lipid profile, self-monitoring, recommender, mobile application, content-based filtering

1 INTRODUCTION

A lipid profile refers to a blood test that provides information about the levels of various types of lipids. The different types of lipids include total cholesterol, low-density lipoprotein cholesterol (LDL), high-density lipoprotein cholesterol (HDL-C), triglycerides, and non-HDL cholesterol [1]. Elevated levels of total cholesterol, LDL, and triglycerides, along with decreased levels of HDL, can increase the risk factors for developing cardiovascular disease (CVD) [2].

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Several studies have highlighted the importance of the lipid profile in the progression of CVD [3–6]. Elevated levels of triglycerides and total cholesterol have been observed to impact the narrowing and hardening of heart vessels, factors closely associated with CVD risk. Additionally, higher levels of low-density lipoprotein cholesterol (LDL-C) have the potential to trigger the development of arteriosclerosis, as they lead to the buildup of LDL-C within the inner layers of artery walls, thus promoting the formation of blood platelets and leading to serious health complications [7]. However, clinical studies have demonstrated that self-monitoring lipid levels are apparently beneficial not only for the secondary prevention of CVD but possibly for the primary prevention [8]. Therefore, patients with lipid disorders should focus on maintaining a healthy lipid profile to protect against the risk of cardiovascular disease.

Lipid management aims to maintain a balanced lipid profile within healthy parameters. To achieve this, individuals are encouraged to engage in self-management practices, such as adopting a nutritious diet, participating in regular physical activity, and consistently monitoring lipid levels [9–11]. Previous research has shown that customized interventions for self-management practices have been successful in promoting self-regulation behaviors related to dietary fat consumption, physical activity, and adherence to screening practices among patients with chronic diseases [8], [12–14]. Therefore, providing personalized interventions to patients with lipid disorders could improve their ability to effectively manage their lipid levels.

Information technology advancements have enabled customized interventions for self-management practices in healthcare. This means that healthcare solutions can be tailored to individual needs, enhancing their efficacy in monitoring different aspects of health, including diet, weight, and fitness activities. Smartphone applications provide convenient access to online information. This connectivity also grants users access to other services, such as location-based services, cameras, and recording features. These features make smartphone applications practical and user-friendly, empowering individuals to manage chronic diseases [15–17].

Several smartphone applications are available that cover a wide range of healthcare, from fitness and nutrition to mental well-being for health improvement. Some applications related to health have included lipid profiles for general information that is not personalized to the user's data [17]. Therefore, developing a tailored smartphone application for patients' with lipid disorders to manage their lipid profile, nutrition, and physical activity can have significant benefits for user health.

This study introduces an approach to enhancing patients' self-management practices through a mobile application and a recommender system called CoLipid. The paper outlines the development of CoLipid, an application that can suggest meal plans and physical activities and monitor lipid profiles based on predetermined health information. The construction of a vector space model serves as a content-filtering technique, recommending meal plans and physical activities to patients based on their similarity score to previous preference information. A preliminary study of CoLiqid's usability was conducted, involving a sample of 32 participants.

2 METHODOLOGY

2.1 Hybrid methodology

We employed a hybrid approach (see Figure 1) that integrates agile and waterfall development techniques. The five phases of the hybrid approach are requirements, design, development, testing, and evaluation. The agile methodology is used for the design, testing, and development phases, while the waterfall methodology is used for the requirements and evaluation stages.

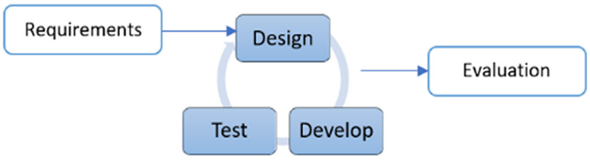

Fig. 1. Hybrid methodology

During the requirement stage, we extensively engaged with healthcare professional stakeholders. We acquired valuable insights through extensive knowledge exchange, discussions, and references to standard practice guidelines and relevant research [18–26]. After extracting domain knowledge and functional requirements, we gathered meal plan data from nutritionist stakeholders at general practice clinics to obtain specialized knowledge and essential specifications. The meal plan data, which included breakfast, morning tea, lunch, teatime, and dinner, was collected in collaboration with nutritionists. Additionally, we obtained exercise activity data from common fitness guidelines.

During the design process, we developed graphical user interfaces and high-level system designs. We utilized recommender algorithms to build the mobile application with a recommender engine during the development phase. We tested the mobile application until we achieved optimal results. In the assessment phase, we evaluated the mobile application prototype using a survey to gauge three usability elements: usefulness, ease of use, and satisfaction [27]. We obtained written informed consent from stakeholders and users for their participation in the study, ensuring compliance with ethical considerations.

2.2 High-level screening system design

A lipid profile mobile application is proposed, which allows patients to perform self-monitoring of lipid profiles and receive recommendations for meal plans and physical activities. Figure 2 illustrates the components of the CoLipid application architecture. There are four components: (1) user input, (2) recommender, (3) report, and (4) admin input. The user input serves as the entry point for users to input personal details. The admin input is the entry point for the admin to input the lipid profile and medication. The recommender corresponds to the user input and admin input, generating recommendations for diet meal plans and exercise plans based on the meal plan and exercise database using a content-based filtering approach. The report calculates and displays the body mass index (BMI) and health report based on admin and user inputs.

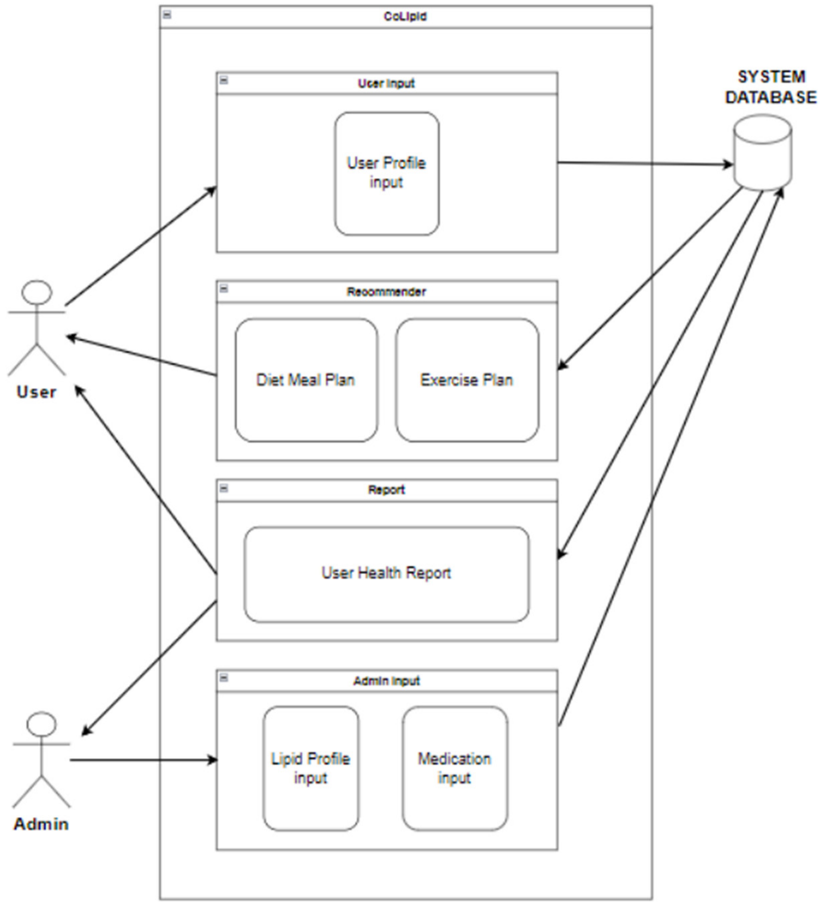

Fig. 2. System architecture

2.3 Recommender algorithm

Algorithms were created to provide personalized recommendations based on a patient's information. A total of six algorithms—one primary algorithm and five sub-algorithms—were developed. The lipid profile management process is included in the primary algorithm. The five sub-algorithms cover meal plans, physical activity, user profile, administration, and medication. The approach used in developing CoLipid involves implementing a content-based filtering technique to create personalized recommendations for meal plans and physical activity [28]. This approach utilizes a vector space model, employing cosine similarity and the TF-IDF ratio [29]. TF-IDF is a weighting mechanism used in vector space models to measure the similarity between keywords by splitting the distance between the document and query vectors [30].

Figure 3 illustrates the TF-IDF weighting formula. This formula considers the frequency of a phrase in a document ($tf_{t,d}$), the number of documents containing the term (df_t), and the total number of documents in the collection (N) to determine the weight ($w(t, d)$) of the term in the document [31].

$$w(t,d) = \frac{tf_{t,d} \, log\left(\frac{N}{df_t}\right)}{\sqrt{\sum_i (tf_{t_i,d})^2 log\left(\frac{N}{df_{t_i}}\right)^2}}$$

Fig. 3. TF-IDF weighting formula [29]

The TF-IDF weighting algorithm in our study utilizes keywords extracted from meal plans or physical activity descriptions to identify related items in the corresponding databases. The algorithm assigns weights to determine the significance and order of items based on their relevance. The item list is then arranged in ascending order according to the similarity score, with a threshold value of 0.2. This means that recommended items must have a minimum similarity score of 20%. Subsequently, selection rules are used to choose the most relevant items. Figure 4 illustrates the application of the TF-IDF method to CoLipid.

1. Loop for word sequence text
2. Declare temporary variable
3. Check temporary variable length > 0
4. Check word fequency vector contain temporary variable
5. Declare frequency1 frequency2
6. Assign frequency1 and frequency2 with values from word frequency vector using temporary variable
7. Read values and create object values
8. Find word frequency vector with values
9. Add disctinct words to temporary variable

Fig. 4. Convert text to vector—TF-IDF algorithm

2.4 Evaluation

We conducted functionality testing to assess the performance of Co-Lipid and a preliminary user evaluation to gauge the usability of Co-Lipid. The functionality testing involved six test cases designed to include input validation, user interface interactions, and data processing, as detailed in Table 1.

Table 1. Co-Lipid test cases

Test Cases #	Test Scenario	Expected Outcome
T001	Click on the log-in button to fill in the phone number	The home page will be display
T002	Click on the lipid profile button or medicine button and insert the inputs	A form will be displayed
T003	Click on the update patient profile and insert input	A form will be displayed
T004	Click the register account button, insert the requirement data	The page will redirect to the patient list at the admin homepage
T005	Click the choose meal or exercise button, choose any preference, and click the generate button	The system will recommend based on user preference
T006	Click report button	All data on lipid profile and body information are displayed on the report page

The preliminary user evaluation required participants to complete an online questionnaire. The target population for the evaluation included end-users, such as patients and medical practitioners. We used convenience sampling to invite potential participants who were available and willing to participate voluntarily via email. We developed a web-based questionnaire to collect responses from participants efficiently, saving time on distributing the questionnaire. The web-based questionnaire consisted of 11 questions and was divided into two sections: (a) demographic and (b) usability. In the demographic section, we asked participants about their backgrounds, including age, gender, and occupation. In the usability section, we required participants to answer questions aimed at measuring three elements of usability: usefulness, ease of use, and satisfaction [27]. We published the questionnaire between October 2022 and January 2023.

Ethical approval. Ethical approval was obtained from the Institutional Research Ethics Committee [Ref: 100-FSKM (PJI.9/10/3) (MR/217)] following the Declaration of Helsinki.

3 RESULTS

The CoLipid mobile application was developed using the hybrid methodology, where an application was built, tested, and evaluated. To gather domain knowledge and functional requirements for CoLipid development, two highly qualified healthcare professionals and two nutritionists were hired during the requirement stage. A recommender system utilizing a content-filtering technique has been incorporated into the CoLipid application.

The preliminary user evaluation was conducted with 32 voluntary participants, comprising 21 females and 11 males. Out of 32 respondents, 22 are between 18 and 25 years old. Six respondents are aged between 40 and 50 years old, while the rest fall within the 26 to 30 year old range. Regarding participants' occupations, 20 respondents are not from the healthcare field, while 12 are healthcare professionals.

The results of functionality testing have indicated that the Co-Lipid functions as intended in every test scenario. All functionality that has been tested has passed, indicating that the system operates as expected in all scenarios. The majority of respondents to the preliminary user evaluation, conducted to assess the usability of the cholesterol monitoring application, provided positive reviews of the program. Most participants responded that they agreed or strongly agreed that the Co-Lipid application was perceived to be highly useful, easy to use, and highly satisfying in terms of usability.

All participants agreed that the CoLipid application is practical for monitoring lipid profiles in healthcare. 95% of the respondents strongly agreed that the CoLipid application met their needs by recommending suitable meal plans and physical activities based on their preferences and lipid profiles. This indicates that the application assists patients in monitoring cholesterol levels, following prescription medication instructions, and reducing risk factors for cardiovascular disease.

After utilizing the features of the lipid profile application, 94% of respondents strongly believe that this application is essential and are eager to recommend it to their friends and family. Figure 5 illustrates that 90% of respondents strongly agree that this application assists in meeting their self-monitoring needs. The remaining respondents expressed a neutral stance on the self-monitoring criteria. The distribution of responses highlights how effectively the application is perceived to support self-monitoring activities.

In terms of user-friendliness, 93% of participants responded that the app is straightforward to use, and the majority responded that the application is consistent while they are using it. All participants also agreed that the application is simple to use. This suggests that the application offers simple, graphical user interfaces with easy-to-use functionalities.

All participants reported satisfaction with the user experience and stated they would recommend the recommender application to others. 93% of participants expressed that they required the app in their daily lives as it could assist them in monitoring various aspects of their health, including nutrition, weight, and exercise routines.

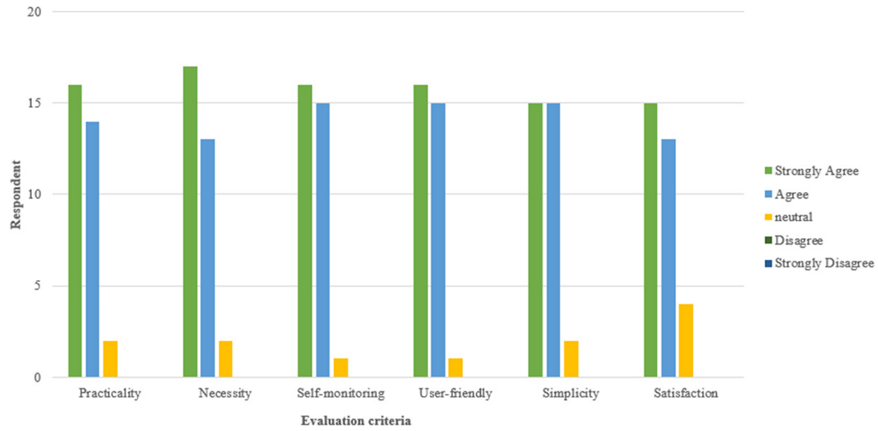

Fig. 5. Responses from CoLipid user evaluation

4 DISCUSSIONS

This study aimed to find a practical method for recommending similar physical activity and meal plans based on lipid profiles and user preferences to promote self-monitoring behaviors without the involvement of healthcare professionals. A recommender system built on the content-filtering method is incorporated into CoLipid. The content-filtering method was created using a vector space model that utilizes meal plans and physical activity description keywords to recommend related meal plans and physical activities. It also employs selection criteria to identify the most similar alternatives.

CoLipid provides users with a platform to monitor their lipid profile while taking medication and receive suggestions for similar eating programs and exercises. Through the provision of knowledge, tracking tools, and resources, this groundbreaking application can enable patients to take an active role in controlling their cardiovascular health. Since it gives users the ability to actively participate in the management of their health, provides individualized assistance, and fosters a better awareness of their cardiovascular health, this application is crucial to the implementation of self-monitoring innovation, particularly in Malaysia. It may result in better health outcomes and a higher standard of living. However, it should be utilized in conjunction with standard medical treatment and competent medical advice.

To assess the usability of the CoLipid application, a preliminary usability evaluation was carried out with a sample of 32 people. In general, 95% of participants concurred that CoLipid is practical in terms of suggesting appropriate meal planning and physical activity. Additionally, 93% of respondents agreed that the application is practical and user-friendly because it is quick, simple, and secure. Most respondents were pleased with how the application helped them track their health and recommended appropriate meal planning and physical activities. Overall, the evaluation study's findings show that the CoLipid application has the potential to be used in healthcare to assist individuals in better understanding their lipid profiles, cholesterol levels, and cardiovascular health.

5 CONCLUSION

The main goal of this study was to determine a practical method for creating personalized physical activity and dietary recommendations based on lipid profiles and user preferences. The aim was to promote self-monitoring behaviors without the need for healthcare specialists. A crucial step in achieving this objective was integrating a content-filtering recommender system into the CoLipid mobile application. This application utilizes a vector space model to efficiently provide meal plans and physical activities by applying relevant keywords and selection criteria. To enhance the accuracy of recommendations, the TF-IDF and cosine similarity algorithms were employed to rank options based on their alignment with user preferences.

The CoLipid application has the potential to enhance healthcare by helping users gain a better understanding of their lipid profiles and how they impact cardiovascular health. It serves as an educational tool for education regarding lipids, raising cholesterol awareness, and promoting cardiovascular health. Future efforts will concentrate on enhancing personalization by refining recommendation algorithms and incorporating wearable health devices to provide real-time data. Priorities for future growth include predictive analytics, heightened security and privacy measures, and continuous long-term health monitoring.

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