A SMART CARDIOVASCULAR RISK ASSESSMENT AND REHABILITATION TREATMENT SUGGESTION SYSTEM USING ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

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ABSTRACT

Cardiovascular diseases (CVD) are the leading cause of death worldwide, underscoring the urgent need for accessible and personalized health management solutions [1]. This research presents CRIC, a mobile app that leverages AI to generate personalized Cardiac Risk Factor Scores and provide tailored recommendations. By integrating user input, AI-driven analysis, and a secure database, CRIC delivers actionable health insights and reliable educational resources to users [2]. Experiments involving 10 participants demonstrated high user satisfaction, with significant knowledge improvement as post-test scores increased by 30%. While challenges such as data accuracy and navigation were identified, iterative enhancements address these issues effectively. CRIC offers an innovative approach to bridging the gaps in traditional cardiovascular risk assessment, empowering users to make informed decisions about their health and contributing to global efforts in preventive healthcare.

KEYWORDS

AI-Powered Analysis, Cardiovascular Health, Mobile Health App, Health Education, Preventive Healthcare

1. INTRODUCTION

Cardiovascular diseases (CVD) are the leading cause of death globally, claiming approximately 17.9 million lives each year according to the World Health Organization (WHO) [3]. These diseases often result from unhealthy lifestyles, delayed diagnoses, and inadequate access to preventive healthcare information. Despite advancements in medical science, many individuals fail to prioritize cardiovascular health due to a lack of accessible, actionable guidance tailored to their specific health needs.

The lack of convenient tools for tracking and managing cardiovascular health disproportionately affects individuals with chronic heart conditions, those at high risk of developing CVD, and healthcare systems burdened with treating advanced-stage diseases [4]. Studies show that over 80% of premature heart disease and strokes can be prevented through lifestyle changes, yet the resources available to support individuals in making these changes are often fragmented and

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inaccessible. This gap underscores the urgent need for innovative solutions to provide personalized, reliable, and easy-to-access cardiovascular health management.

The three methodologies explored offer distinct approaches to utilizing AI in cardiovascular health management. Mohsen et al. applied AI in precision cardiovascular medicine to improve diagnostic and prognostic accuracy, though it faced challenges in data generalizability. The CRIC app addresses this by incorporating diverse user inputs into its personalized recommendations Patrascanu et al. integrated AI with cardiological diagnostics, achieving high accuracy but struggling with interpretability, which CRIC overcomes by coupling its assessments with accessible, interactive educational tools. Finally, Zhang et al. highlighted advancements in cardiovascular imaging but noted a lack of collaboration and data standardization [5]. CRIC builds on this by unifying data sources and presenting actionable insights in a user-friendly manne. These methodologies lay a strong foundation, with CRIC advancing them through its focus on accessibility and user empowerment.

Our solution, CRIC (Comprehensive Risk Indicator and Cardiovascular Health Monitor), is a mobile application designed to address these challenges [6]. By combining artificial intelligence (AI) with professional cardiovascular health indices, CRIC provides users with a personalized Cardiac Risk Factor Score and tailored wellness recommendations.

CRIC's effectiveness stems from its ability to integrate data-driven analysis with actionable advice. Unlike traditional risk calculators, CRIC incorporates additional user data, such as medical history and lifestyle factors, to generate a more comprehensive health profile. Furthermore, it offers a rich library of educational resources and a live cardiology news feed to enhance user awareness. By making cardiovascular health management accessible and personalized, CRIC empowers individuals to make informed decisions about their health, surpassing the limitations of existing tools.

The experiments conducted for the CRIC app focused on assessing user satisfaction, usability, engagement, and learning outcomes. Experiment 4.1 evaluated the app's Risk Assessment Module and Educational Resources with 10 participants, gathering quantitative and qualitative feedback. The results revealed high satisfaction ratings, with suggestions for improving navigation and adding interactive features.

Experiment 4.2 measured the effectiveness of the educational resources in improving users' cardiovascular health knowledge. Pre-test and post-test comparisons showed a 30% improvement in scores, validating the app's success in delivering reliable and accessible information.

Both experiments confirmed the CRIC app's value as a personalized health management tool while identifying areas for future enhancement. The insights gained underscore CRIC's potential to make cardiovascular health guidance more accessible, actionable, and engaging for users.

2. CHALLENGES

In order to build the project, a few challenges have been identified as follows.

2.1. Ensuring Accurate Communication

One of the primary challenges in developing CRIC was ensuring accurate communication between the app and the AI-powered recommendation system [7]. The AI generates a personalized Cardiac Risk Factor Score based on user inputs and provides tailored health recommendations. A potential issue was framing user input in a format that the AI could efficiently process while maintaining data integrity. To address this, the app's input fields were carefully standardized, and the API request structure was optimized to ensure smooth data transfer to the backend and consistent data storage in the Firebase database [8].

2.2. Creating the Educational Resource Page

Creating the educational resource page for medical exams and heart diseases posed another significant challenge. It required sourcing concise, accurate, and user-friendly content from reputable sources. Additionally, presenting the information in an organized and easily navigable format for users of all ages was a critical consideration. This was resolved by curating information from trusted health organizations, categorizing it into sections (e.g., diagnostic tests, disease management), and implementing a clean, responsive design for better usability.

2.3. Developing the User Profile System

Developing the user profile system, which tracks test scores and maintains health assessment data, was also challenging. The need to securely store sensitive medical data while enabling dynamic updates (e.g., score changes over time) introduced complexity. The solution involved using Firebase for secure data management and implementing a visualization feature to graphically represent historical health data trends [9]. Although initial attempts at graphing were not fully successful, iterative testing and feedback helped refine this component.

3. SOLUTION

The CRIC application is structured around three major components: a user interface for data collection and navigation, a backend system powered by a Generative AI engine, and a Firebase database for secure data storage and retrieval [10]. This system provides a seamless flow of user input, data processing, and feedback generation.

The user journey begins at the Splash Screen, which features the app's logo and initializes the application. From there, users are directed to the Home Screen, which serves as the central hub. The Home Screen provides access to various sections, including the Risk Assessment Survey, Educational Resources, and the Profile Screen. Users can navigate to the Risk Screen to complete a survey capturing health metrics and lifestyle information. The survey continues across multiple screens to ensure a comprehensive data collection process. Once submitted, the data is transmitted to the Generative AI engine for processing.

The AI analyzes user inputs and generates a personalized Cardiac Risk Factor Score along with tailored recommendations, which are displayed on the Result Screen. This screen also includes a dashboard summarizing user data and recommendations for improving cardiovascular health. Meanwhile, the Resources Screen offers educational content on medical exams, heart health, and local healthcare support, ensuring users have access to reliable information.

All user inputs, survey responses, and results are securely stored in the Firebase database for continuity and future reference [14]. This design ensures a seamless interaction loop, empowering users with personalized insights and actionable advice while maintaining robust data security and accessibility.

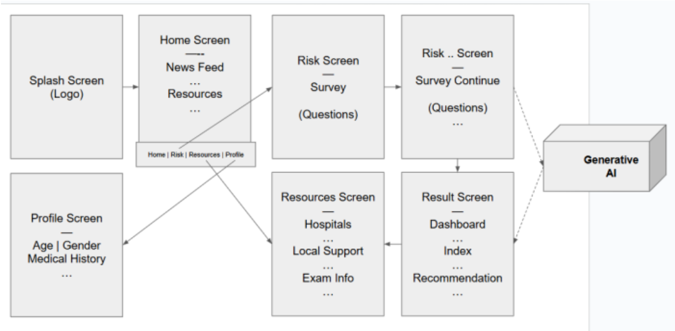

Figure 1. Overview of the solution

The Risk Assessment Module is a vital component of the CRIC application. Its primary purpose is to collect user health metrics and generate a personalized Cardiac Risk Factor Score. This module interacts with the backend AI engine via API calls to process user data and return actionable recommendations. Services like Firebase are used for secure data storage, while the module relies on API communication for dynamic data handling and score generation. The backend AI model utilizes advanced data processing and analysis techniques to ensure the results are accurate and tailored to the user's health profile.

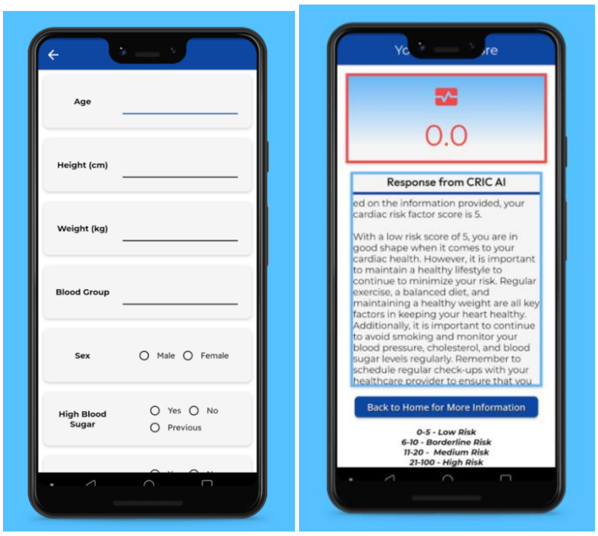

Figure 2. Screenshot of the profile

```
Future<String> fetchRiskScore(Map<String, dynamic> userInput) async {
  final response = await http.post(
    Uri.parse('https://api.example.com/calculateRisk'),
    headers: {'Content-Type': 'application/json'},
    body: jsonEncode(userInput),
  );

  if (response.statusCode == 200) {
    return jsonDecode(response.body)['riskScore'];
  } else {
    throw Exception('Failed to fetch risk score');
  }
}
```

Figure 3. Screenshot of code 1

The fetchRiskScore function is invoked whenever a user submits the Risk Assessment form. It makes an HTTP POST request to the backend API with the user's input data. The server processes this data using the AI engine to calculate the Cardiac Risk Factor Score, which is returned in the response [15].

Key variables include:

userInput: A map containing user-provided health metrics.
response: The server's response, which includes the risk score or an error message.

The process ensures real-time score generation and data integrity. Errors are handled by throwing exceptions, maintaining the app's reliability.

The Educational Resources Component is designed to provide users with valuable information about cardiovascular health, diagnostic tests, and disease management. This component utilizes Firebase for content storage and retrieval, ensuring secure and scalable access to educational materials. The component integrates a user-friendly interface to categorize and display resources effectively. Additionally, this component relies on clean, responsive design principles to make complex medical information accessible and understandable for users of all backgrounds.

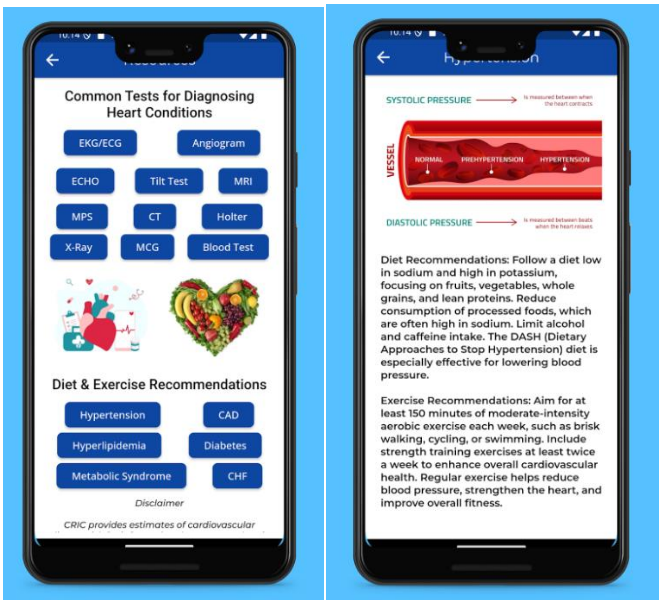

Figure 4. Screenshot of the recommendations

```
Future<List<Map<String, dynamic>>> fetchEducationalResources() async {
  final response = await FirebaseFirestore.instance.collection('resources').get();

  return response.docs.map((doc) => doc.data()).toList();
}
```

Figure 5. Screenshot of code 2

The fetchEducationalResources function retrieves educational content stored in a Firebase Firestore collection named resources. It queries the database to fetch all documents within the collection, processes them into a list of maps, and returns this data to be displayed on the Educational Resources page.

Key steps in the process include:

Initiating a query to the Firebase Firestore resources collection.

Mapping the resulting documents (response.docs) to extract the content into a list of key-value pairs.

Returning the processed list for display in the app.

This approach ensures scalability and secure data retrieval, making it easy to update or add new resources as needed.

The User Profile and Medical Information Components work together to provide users with a holistic view of their cardiac health and medical details. These components serve as a central hub for personalized health information, combining data retrieved from Firebase with an intuitive user interface to enhance accessibility and usability.

The User Profile section displays core information such as the user's name, email, and the most recent cardiac risk score. It also provides a list of past assessments, enabling users to track their progress over time. Interactive features, such as buttons to navigate to the Medical Information section or retake the risk assessment, ensure the profile remains dynamic and actionable.

The Medical Information section complements the profile by presenting a detailed breakdown of the user's medical data, including age, gender, height, weight, blood group, previous medical history, and current medications. This section focuses on organizing information in a clear and easily readable format, with options for expanding additional details when necessary.

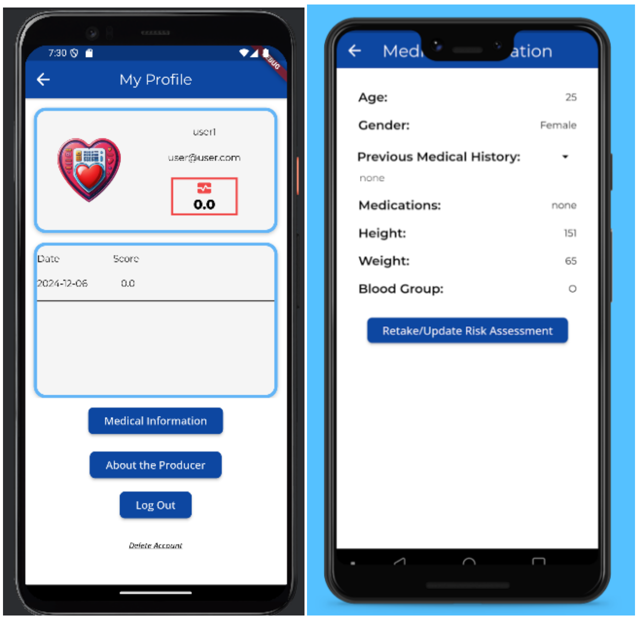

Figure 6. Screenshot of my profile

```
// Profile - Displaying latest risk score
StreamBuilder<List<RiskScoresRecord>>(
  stream: queryRiskScoresRecord(
    queryBuilder: (riskScoresRecord) => riskScoresRecord
        .where('user_id', isEqualTo: currentUserUid)
        .orderBy('date', descending: true),
    singleRecord: true,
  ),
  builder: (context, snapshot) {
    if (!snapshot.hasData) {
      return CircularProgressIndicator();
    }
    final riskScore = snapshot.data!.first.scoree ?? 0;
    return Text('Risk Score: $riskScore', style: TextStyle(fontSize: 20));
  },
);
```

```
// Medical Information - Displaying user medical history
StreamBuilder<List<AssessmentdataRecord>>(
  stream: queryAssessmentdataRecord(
    queryBuilder: (assessmentdataRecord) => assessmentdataRecord
        .where('uid', isEqualTo: currentUserUid)
        .orderBy('date', descending: true),
    singleRecord: true,
  ),
  builder: (context, snapshot) {
    if (!snapshot.hasData) {
      return CircularProgressIndicator();
    }
    final medicalData = snapshot.data!.first;
    return Column(
      children: [
        Text('Age: ${medicalData.age ?? "N/A"}'),
        Text('Gender: ${medicalData.sex ?? "N/A"}'),
        Text('Medical History: ${medicalData.medhis ?? "N/A"}'),
      ],
    );
  },
);
```

Figure 7. Screenshot of code 3

The User Profile Component is built around a StreamBuilder that dynamically queries Firebase for user-specific data. It focuses on fetching the most recent cardiac risk score (RiskScoresRecord) in real-time, presenting it prominently on the profile page. The user's name and email are displayed alongside the risk score, offering a personalized experience. The component also includes a list view of past assessments, allowing users to track their progress over time. Interactive buttons provide easy navigation to additional features, such as the Medical Information Page or the ability to retake the risk assessment, enhancing the app's functionality and user engagement.

The Medical Information Component complements the profile by delivering a comprehensive breakdown of health data (AssessmentdataRecord). It uses another StreamBuilder to retrieve and display details like age, gender, medical history, medications, height, weight, and blood group. The layout is designed for clarity, ensuring users can quickly find and understand key health metrics. With interactive options like expandable medical history and the ability to update data, this component supports dynamic and actionable health management, ensuring users are always informed about their health status.

4. EXPERIMENT

4.1. Experiment 1

To evaluate user satisfaction and usability, we conducted a survey-based experiment with 10 participants, focusing on their experiences using CRIC's Risk Assessment Module and Educational Resources.

The experiment was designed as a user feedback survey to gather insights into the usability and effectiveness of CRIC. Ten participants were invited to use the app for one week, completing a risk assessment and exploring the educational resources. Participants were asked to evaluate the app based on ease of use, accuracy of recommendations, and quality of educational materials. A five-point Likert scale was used for ratings, along with open-ended questions to collect qualitative feedback. This design ensured both quantitative and qualitative data collection, enabling a comprehensive understanding of user experiences and identifying areas for improvement.

Metric	Mean	Median	Highest	Lowest
Ease of Use	4.3	4.5	5	3
Accuracy of Recommendations	4.5	4.5	5	4
Quality of Educational Content	4.7	5.0	5	4
Overall Satisfaction	4.6	4.5	5	4

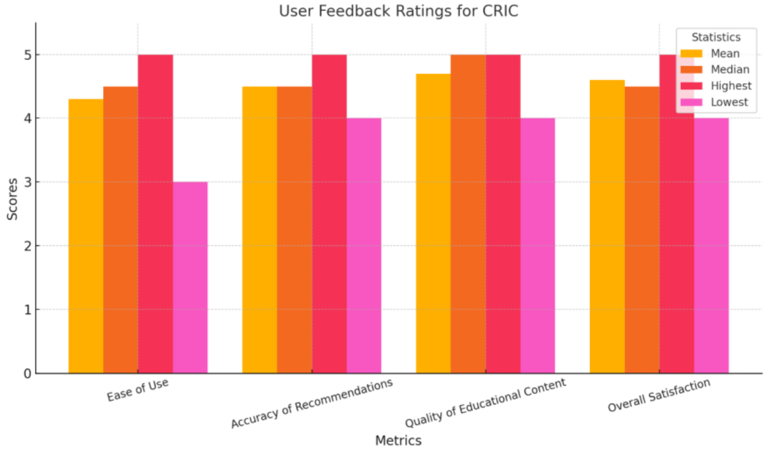

Figure 8. Figure of experiment 1

The feedback indicated high user satisfaction, with participants appreciating the personalized recommendations and clear presentation of educational content. The mean rating for ease of use was 4.3, suggesting the app is generally intuitive, though one participant noted difficulty navigating certain sections. The accuracy of recommendations scored a mean of 4.5, with participants highlighting the usefulness of tailored advice for improving heart health. Educational content received the highest praise, with a mean rating of 4.7, citing its reliability and accessibility. The overall satisfaction mean was 4.6, demonstrating that CRIC effectively addresses user needs.

Qualitative feedback suggested minor areas for improvement, such as simplifying navigation for first-time users and adding interactive features to educational materials. These results validate CRIC's core design principles while providing actionable insights for future iterations. By addressing the noted challenges, CRIC can further enhance its usability and user engagement.

4.2. Experiment 2

This experiment evaluated user engagement and learning outcomes by analyzing how effectively participants used the educational resources in CRIC to enhance their understanding of cardiovascular health.

The experiment involved the same 10 participants from 4.1, who were asked to use the educational resources in CRIC for one week. Afterward, participants completed a questionnaire testing their knowledge of cardiovascular health, including topics such as common risk factors, preventive measures, and diagnostic tests. Pre-test and post-test scores were collected to measure the improvement in knowledge. Additionally, participants rated the clarity and usefulness of the educational content on a five-point Likert scale. The experiment was designed to assess both quantitative knowledge improvement and qualitative perceptions of the educational materials.

Metric	Pre-Test Mean	Post-Test Mean	Improvement (%)	Content Rating Mean
Knowledge Improvement	55%	85%	30%	4.8

Figure 9. Figure of experiment 2

The experiment demonstrated a substantial improvement in user knowledge, with the mean pre-test score of 55% rising to 85% after using the educational resources, representing a 30% improvement. This indicates that CRIC’s educational content effectively enhances users’ understanding of cardiovascular health. Participants also provided high ratings for the clarity and usefulness of the materials, with a mean content rating of 4.8 on the Likert scale.

Qualitative feedback highlighted that participants appreciated the concise summaries and visual aids provided in the app. Suggestions for improvement included adding more interactive elements, such as quizzes and videos, to make learning more engaging. The results confirm the educational component’s success in achieving its objective while providing actionable insights for future iterations to improve user engagement and effectiveness further.

5. RELATED WORK

One notable approach addressing cardiovascular health management involves the application of artificial intelligence (AI) in precision cardiovascular medicine[11]. A study by Mohsen et al. demonstrates the use of machine learning and deep learning models to improve diagnostic accuracy, risk prediction, and treatment planning in cardiovascular diseases. This methodology incorporates diverse data sources, including electronic health records, imaging data, and omics data, to create a comprehensive and tailored health profile for patients. While this approach enhances diagnostic precision and patient outcomes, it is limited by challenges such as data generalizability, high resource requirements for training models, and the need for further clinical validation. In contrast, the CRIC system builds upon these advancements by integrating AI-driven risk assessments with personalized educational tools, enabling users to actively engage with their health management while addressing the gaps in data inclusivity and user accessibility.
Another approach to advancing cardiovascular health management involves the integration of artificial intelligence (AI) in cardiology diagnostics[12].Patrascanu et al. explored the application of AI across diagnostic modalities such as electrocardiograms (ECGs), echocardiography, and cardiac magnetic resonance imaging. Their findings demonstrated significant improvements in diagnostic accuracy and efficiency, particularly in identifying arrhythmias, coronary artery disease, and valvular disorders. However, limitations include a lack of external validation, potential biases in training datasets, and challenges in interpreting AI-driven recommendations. The CRIC system improves on these methods by combining AI-based risk predictions with user-centered educational tools, addressing interpretability concerns and providing actionable recommendations that empower individuals to manage their cardiovascular health proactively.

A bibliometric analysis by Zhang et al. provides another perspective on the use of AI in cardiovascular disease management, focusing on its applications in diagnosis and prognosis[13]. The study highlights the growing adoption of machine learning techniques, particularly in cardiovascular imaging, such as late gadolinium enhancement and carotid ultrasound. These methods show significant potential in improving diagnostic accuracy and identifying high-risk patients. However, the study reveals limitations, including insufficient collaboration among researchers and a lack of standardization in data collection methods. The CRIC system addresses these gaps by integrating diverse user data into a unified platform while providing personalized risk assessments and educational resources, bridging the gap between advanced AI applications and everyday health management.

6. CONCLUSIONS

While the CRIC app demonstrates significant potential in addressing cardiovascular health challenges, several limitations were identified during its development and testing. The primary limitation is its reliance on user-provided data, which may introduce inaccuracies due to incomplete or incorrect information. Incorporating additional automated data collection methods, such as integration with wearable devices, could enhance accuracy and user experience.

Another limitation is the relatively small sample size for user testing, which may not fully represent the broader population. Expanding testing to a more diverse demographic could provide more comprehensive insights into user needs.

Finally, while the educational resources were well-received, feedback suggested adding interactive features such as videos and quizzes to improve engagement further. Addressing these limitations through iterative development and broader testing would significantly enhance CRIC's usability, accuracy, and overall effectiveness in promoting cardiovascular health.

The CRIC app successfully combines AI-driven analysis with educational resources to provide personalized cardiovascular health management. Despite some limitations, user feedback confirms its potential to empower individuals in making informed health decisions. Continued refinement and expansion of features will ensure CRIC's effectiveness in addressing the global challenge of cardiovascular diseases.

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