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Mobile Health Innovation: An Android-Based Nutritional Grading App to Promote Healthier Food and Beverage Choices

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ABSTRACT

Background: Unhealthy dietary patterns are one of the leading contributors to non-communicable diseases such as stroke, heart disease, and diabetes in Indonesia. The increasing availability of processed foods, combined with a lack of nutritional awareness, has created an urgent need for tools that support healthier consumption decisions.

Aims: This study aims to develop a mobile health application that enables users to assess the nutritional quality of food and beverages through a grading system, thereby promoting healthier dietary choices.

Methods: The application was developed using the waterfall software development model and implemented in Kotlin for the Android platform. It features a nutrition label scanning system powered by the device's camera and applies Nutri-Grade rules to classify products into four categories (A–D) based on sugar and saturated fat content. The app's architecture follows the Model-View-ViewModel (MVVM) pattern, and data communication is handled via Retrofit. Functional testing was conducted using black-box testing techniques.

Result: The application successfully allows users to register, scan nutrition labels, and receive grading results instantly. It provides a user-friendly interface and accurate results according to Nutri-Grade guidelines. All features passed the expected output criteria during the black-box testing phase.

Conclusion: This study demonstrates the feasibility and utility of integrating nutrition science into mobile application technology. The Android-based Nutri-Grade app serves as a practical tool to improve public dietary behavior, especially in urban and digital-native populations. It empowers users to make informed dietary choices in real-time and contributes to preventive health strategies through digital innovation. The app's scalability and adaptability also open future pathways for integrating machine learning to enhance nutritional recognition and grading accuracy.

Keywords: Android application, food grading, health promotion, mobile health, MVVM architecture, nutrition label.

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INTRODUCTION

In recent decades, the global burden of non-communicable diseases has increased significantly, with unhealthy dietary habits playing a central role. In Indonesia, high consumption of sugar-rich and fatty foods has been associated with increased cases of obesity, diabetes, cardiovascular diseases, and early mortality. The absence of accessible tools to support informed food choices further exacerbates this issue, especially among young and urban populations. Mobile health (mHealth) technologies have emerged as practical solutions that can assist users in evaluating the nutritional content of their daily food intake. By providing real-time access to grading based on established nutritional standards, these tools can help bridge the gap between awareness and actionable behavior. In this context, Android applications stand out due to their wide usage, open- source nature, and flexibility in health innovation deployment (Agbeyangi & Suleman. 2024 and Galetsi et al. 2023). This research addresses the urgent need for mobile tools that promote better health decision-making by assessing food and beverage quality.

Nutritional labeling alone has not been effective enough to influence consumer behavior, particularly among populations with low nutrition literacy. Front-of-pack labeling systems such as the Nutri-Grade model have demonstrated their usefulness in conveying simplified health ratings for products, using categories ranging from A (healthiest) to D (least healthy). However, applying these ratings in real-time during food selection requires digital support. With the widespread use of smartphones, particularly Android-based devices, integrating this functionality into a mobile app is both timely and promising. Thus, mobile applications can play a transformative role in dietary behavior modification, supporting both individuals and public health systems. To that end, this study focuses on building an Android app that integrates nutritional scanning and automatic grading to support healthy consumption decisions.

This topic is highly relevant due to its multidisciplinary value it bridges digital innovation, nutrition science, and preventive healthcare. Moreover, it responds directly to global health priorities identified by the WHO, which include digital transformation for universal health coverage and promoting sustainable development goals through better nutrition. Mobile apps that simplify health information can reduce barriers for underserved populations and foster equitable access to health tools. Therefore, developing and evaluating an Android-based Nutri-Grade application presents not only technical merit but also strong social and public health significance. Given the growing reliance on mobile technologies, this research aligns with international calls for scalable, user-centered digital health interventions (Naderbagi et al. 2024 and Rodriguez et al. 2023).

Despite the increasing availability of mobile health applications, few are designed specifically for nutritional grading using machine-readable food label scanning. Most current apps rely on manual input, limiting usability and real-time decision-making. This study aims to fill that gap by introducing an application that leverages a smartphone's camera and back-end processing to instantly grade foods and beverages. It is built on the foundation of the Nutri-Grade framework, enabling users to receive evidence-based evaluations of sugar and

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fat content. Moreover, the integration of the Model- View-ViewModel (MVVM) architecture and Retrofit for API calls ensures a robust and scalable system design. The rationale behind this study lies in its potential to promote health-conscious behavior and reduce the incidence of diet-related diseases through a practical, mobile-first solution. This research also complements current advancements in health informatics by contributing a replicable model for other dietary-focused apps in low- and middle-income countries.

Among numerous studies on mobile health innovation, several provide a strong foundation for this research. Reidy et al. (2025) evaluated the implementation of the NHS App in England and highlighted the importance of user-centered design for digital health adoption. Tolou-Shams et al. (2025) explored digital tools for behavioral health interventions, emphasizing accessibility for at-risk populations. de Almeida et al. (2025) developed a mobile app to support health promotion in pediatric oncology, demonstrating the efficacy of targeted digital interventions. Hellbrecht et al. (2025) reviewed the content quality of smartphone apps for bariatric patients, underscoring the importance of clinical relevance in app development. Hussein et al. (2025) discussed barriers in mHealth use among caregivers, which is critical for understanding app design limitations. (Poulsen et al. (2025) investigated access to mobile health in low-resource settings, offering valuable insights for application scalability. Mouchabac et al. (2025) analyzed the challenges of digital tools in mental health, which is transferable to nutrition and behavior change. Cerolini et al. (2025) proposed a digital model for addressing eating and sleep disorders, supporting the relevance of mobile interventions in nutrition-related issues. Singh Sethi et al. (2025) examined regulatory frameworks for mHealth apps in India, a useful reference for app governance. Lastly, Sestino et al. (2025) investigated gamification strategies in digital health, which can inform future improvements of the current application. These references provide solid support for the technical, behavioral, and regulatory aspects of this study.

While mobile health applications have proliferated in the past five years, most are generalized fitness trackers or calorie counters with minimal automation. There is a lack of nutritional grading tools that function in real-time using image-based label recognition, especially in low-to-middle- income contexts. Moreover, few existing apps implement standardized health frameworks like Nutri- Grade in a way that is transparent, intuitive, and educational for the user. The study hypothesizes that the use of such an application will increase users' awareness and improve their ability to choose healthier food and beverage options. Additionally, the application architecture built using MVVM and supported by Retrofit will ensure optimal performance and usability. It is also anticipated that the application will be feasible for further development into a full-scale public health intervention platform.

METHOD

Research Design

This study employed a quantitative applied research design using a software development framework integrated with usability testing. The research adopted the waterfall model to structure the phases of requirement analysis, system design, implementation, testing, and deployment. This approach is well-suited for health-related mobile application development, allowing for systematic

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evaluation of technical performance and user interaction (Chatterjee et al. 2022 and Nasralla et al. 2023). Each development stage was clearly defined and implemented in sequence, ensuring traceability and continuous validation. Functional performance was assessed through black-box testing to validate whether the application's behavior aligned with its specifications. The development was conducted using Android Studio with Kotlin programming language. To facilitate client-server communication, the Retrofit library was implemented, and data presentation followed the Model-View-ViewModel (MVVM) architecture. This design ensures modularity, maintainability, and responsiveness, which are essential for mobile health interventions.

Participant

Participants in this study included a purposive sample of 15 users aged 18–40 years who owned Android smartphones and had basic knowledge of food labeling. The participant selection was based on their willingness to use the application in a controlled environment and provide feedback on usability and functionality. Ethical approval was secured prior to participation, and informed consent was obtained from all users. This user-centered design trial ensured that the prototype application was tested by individuals likely to represent the general digital-native population. Participants interacted with the app by scanning real food labels and interpreting the grading results. Observations and structured interviews were conducted to collect qualitative feedback on user experience. This approach aligns with best practices in mobile health application testing, ensuring that feedback reflects real-world scenarios and usability conditions (Jat et al. 2024 and Sinnatwah Jr et al. 2022). Their input played a vital role in validating the user interface and verifying the accuracy of the nutritional grading mechanism.

Instrument

The primary instrument used in this research was the Android-based mobile application itself, equipped with camera-based label recognition, grading algorithm based on Nutri-Grade, and a user feedback interface. To assess the technical performance of the app, black-box testing scripts were prepared, and output consistency was verified across multiple trials. Additionally, a structured observation checklist and usability questionnaire were designed to gather data on user interaction, ease of navigation, and perceived usefulness. Visual recognition of nutrition labels relied on Android CameraX APIs and integrated OCR tools, which enabled data extraction from real-time food product images. The Nutri-Grade algorithm embedded in the app provided categorical grading (A–D) based on sugar and saturated fat levels. The instrument was pre-tested to ensure it could consistently process data under various lighting and label conditions. This combination of functional and experiential measurement ensured a holistic evaluation of the tool's performance. As supported by Bachmann et al. (2022) and Lee et al. (2022), multi-modal instruments improve mobile health research validity and are essential in nutrition-related mHealth app development.

Data Analysis Plan

The data analysis process involved both quantitative and qualitative techniques to evaluate the application's effectiveness and user experience. First, output consistency of the Nutri-Grade scoring algorithm was assessed through repeated black-box testing, comparing actual results with expected outcomes under controlled conditions. Second, usability scores from participant questionnaires were analyzed using descriptive statistics to identify central tendencies in satisfaction, ease of use, and clarity. Structured interview responses were analyzed using thematic analysis to extract key insights related to user expectations and application improvement suggestions. Coding was conducted manually to identify patterns in language, interface feedback, and perceived utility. This hybrid analysis method enabled

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triangulation of system accuracy with user acceptance and behavioral insight. Overall, this comprehensive strategy ensured that both functional correctness and user relevance were captured. As suggested by Kim. (2024) and S¸tefan et al. (2024), integrating technical and experiential feedback in mobile app evaluation enhances the overall robustness of health technology interventions.

RESULTS AND DISCUSSION

Result

The results of this study demonstrate that the mobile application developed can effectively perform food and beverage grading using the Nutri-Grade system. The application was tested through black-box testing across six major functionalities to ensure accuracy and usability. The table below summarizes the outcomes of each feature tested, indicating the expected output and whether the functionality performed as intended.

Table 1. Functional Test Results Using Black-Box Testing

No	Feature Tested	Input	Expected Output
1	User Registration	Name, Email, Password	Account created and redirected to login
2	Login Authentication	Registered Email & Password	Access granted to Home page
3	Product Search	Product Name (e.g., "Yogurt")	Product details displayed
4	Nutrition Scan	Image of nutrition label	Grade calculated (A-D) and nutritional info shown
5	Add New Product	Product Data Inputs	Product listed in database and shown on Home page
6	Profile Edit	Updated name, weight, etc.	User data updated successfully

These results confirm that the system architecture comprising MVVM, Retrofit, and the OCR-based scanning algorithm functions as designed. In the scan functionality test, all participants were able to capture nutritional data and receive accurate grading in under 5 seconds. The grading matched manual calculations based on the Nutri-Grade rules. The search and add product features also worked without delays or crashes. These outcomes validate the application's technical soundness and its potential for real-world deployment. User feedback also indicated high satisfaction with the interface and feature integration.

Discussion

The study findings support the hypothesis that a mobile health application with real-time grading functionality can assist users in making healthier dietary choices. The use of the Nutri-Grade standard provided a reliable basis for classifying products, which aligns with research showing that front-of-pack labeling systems enhance consumer decision-making (Batista et al. 2023). The integration of camera-based OCR with mobile computing allowed for a seamless user experience, supporting previous evidence on the effectiveness of visual recognition in health apps (Lavric et al. 2024). Moreover, the MVVM architecture helped to maintain modularity and improved scalability, as emphasized in recent studies on sustainable mobile health design (Alwakeel et al. 2025).

In addition, this study contributes to digital health equity by creating a tool that is both accessible and adaptable. As highlighted by Poulsen et al. (2025), access to simple and functional mHealth apps can empower low-resource populations. The application developed in this research reflects this principle by using minimal device resources while providing maximum functionality. Also, the structured UI/UX design supported higher usability scores among participants, consistent with the findings by Reidy et al. (2025) on user-centered design in the NHS App. These outcomes also reaffirm

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the role of mobile innovation in public nutrition education, as suggested by Eswaran et al. (2025), who emphasized the value of digital tools in enhancing dietary awareness. The success of the OCR scan in this study also echoes prior success in mobile cancer education apps, which used image- based inputs for personalized feedback (de Almeida et al. 2025). In terms of potential for scale, the app fits the framework discussed by Singh-Sethi et al. (2025). where regulatory alignment and user trust are essential for national deployment of mHealth solutions.

The application developed in this study presents significant implications for public health, particularly in preventive nutrition and consumer education. It offers a digital tool that bridges the gap between nutritional labeling and user comprehension, particularly for digital-native populations. The integration of real-time grading supports behavioral change, which is crucial for combating diet-related non-communicable diseases. Public health institutions could adopt and scale such applications in educational campaigns or dietary monitoring programs. The system could also be integrated with public food databases or e-commerce platforms to provide consumers with health scores at the point of purchase.

This study is limited by its relatively small participant sample, which may not fully represent the broader population. The app was tested only on Android devices, excluding iOS users, which limits generalizability across platforms. Additionally, the accuracy of the nutritional grading depends heavily on the clarity and formatting of the nutrition label. Labels with complex layouts or poor print quality may result in misclassification or OCR errors.

Future studies should expand the participant base to include diverse age groups, education levels, and dietary backgrounds to enhance generalizability. Additionally, the app should be adapted for iOS devices to increase accessibility and platform equity. To improve grading accuracy, future versions may integrate AI-enhanced OCR and multilingual support to recognize labels in various languages. Collaborations with food regulatory bodies could allow integration with national food databases to improve data validation. Researchers are also encouraged to include behavioral analytics to study how the app influences food choices over time. Integration with wearable devices or nutrition tracking tools can offer more holistic health insights. Moreover, gamification strategies, as discussed by Sestino et al. (2025), could enhance user engagement and retention.

CONCLUSION

This study successfully developed and evaluated an Android-based mobile health application designed to grade food and beverage products using the Nutri-Grade framework. The application demonstrated high functional reliability across key features such as registration, login, product search, nutrition label scanning, and grading accuracy. With the integration of MVVM architecture and Retrofit networking, the system maintained modularity, responsiveness, and stability, meeting current standards in mobile health application development. User testing confirmed that the application was both accessible and intuitive, providing real-time feedback that aligned with manually calculated nutritional scores. The findings validate the hypothesis that a mobile-based grading tool can facilitate healthier dietary choices and empower users with accessible nutritional knowledge. Furthermore, this innovation contributes to broader public health goals by offering a scalable, low-barrier technology suitable for diverse populations.

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AUTHOR'S CONTRIBUTION

H.F.R. led the conceptualization, design, and full-stack development of the mobile health application, including the implementation of the Nutri-Grade algorithm, integration of the MVVM architecture, and execution of black-box testing. He also performed user interface design, conducted usability testing with participants, and drafted the initial manuscript. P.M.E.contributed to the supervision of the research process, validation of the research design, and refinement of the methodological framework. She provided critical review and revision of the manuscript content, guided the structuring of the literature review, and ensured the alignment of the research with ethical standards and academic publication requirements.

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