Original Article

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NCDs Screening App: PBRI Model for Primary Care

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Abstract:

Objective: This research study aimed to (1) develop a user-friendly screening application for the identification of individuals at risk for diabetes, hypertension, and depression based on the Praboromarajchanok (PBRI) model; and (2) investigate the prevalence of these conditions among residents in Health Regions 1 and 2 using the developed application.

Material and Methods: A two-phase research and development (R&D) design was employed. In Phase 1, the screening application was developed following the five steps of the PBRI model. The app was expert-reviewed and pilot-tested with 30 users. In Phase 2, the app was used to assess the prevalence of diabetes, hypertension, and depression among 420 target participants.

Results: The resulting "Non-communicable diseases (NCDs) Screening App" is a web-based tool that incorporates clinical practice guidelines for the target NCDs, and features a seven-color "traffic light" PBRI model for risk level visualization, as well as educational videos and user manuals. Expert evaluations confirmed the high quality of the application, and a high user satisfaction score (4.56±0.19) was obtained by pilot testing. In a larger test sample, the percentage of participants

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assigned a pale green risk level was highest for hypertension (37.14%), followed by depression (32.38%) and diabetes (22.62%). Overall, user satisfaction during NCD prevalence screening was also high (4.34±0.41).

Conclusion: The PBRI-based NCDs Screening App has significant potential as a digital tool for early detection and health promotion in primary care settings. It supports the work of village healthcare volunteers and healthcare providers in proactive, community-based screening and education.

Keywords: depression, diabetes, hypertension, non-communicable diseases, PBRI Model, primary care

Introduction

Non-communicable diseases (NCDs), including diabetes, hypertension, and depression, constitute a major global health burden and are associated with high morbidity and mortality, particularly in low- and middle-income countries. Because of this, the World Health Organization has called for the development of innovative, scalable solutions to tackle the growing incidence of NCDs and improve early detection, especially in primary healthcare settings[1]. Digital healthcare technologies, such as web-based and mobile applications, are increasingly recognized as effective tools for the early identification and management of NCDs. Recent studies have shown that app-based platforms and artificial intelligence-driven screening models can enhance risk prediction, self-management, and timely intervention for chronic health conditions in diverse populations[2-4].

The seven-color "traffic light" Praboromarajchanok (PBRI) model, developed by the Praboromarajchanok Institute under the guidance of the Ministry of Public Health of Thailand, serves as an innovative framework for stratifying individual risk for NCDs in primary care and community settings, particularly for hypertension and diabetes. The model employs a color-coded scale, ranging from white to black, to guide risk assessment and promote timely intervention[5]. Under the leadership of Professor Vichai Tienthavorn, the Praboromarajchanok Institute has advanced national health policy in Thailand by integrating behavior-changing communication tools and addressing the maldistribution of healthcare workers in rural areas. These efforts have contributed significantly to the improvement of health equity and system responsiveness. In 2024, the World Health Organization awarded the Sasakawa Health Prize to the Praboromarajchanok Institute in recognition of its contributions to strengthening healthcare systems[6].

The PBRI model can successfully mobilize communities and advance people-centered care, particularly in low-resource contexts[7,8]. The integration of digital screening tools and risk visualization models fosters better communication and shared understanding between healthcare providers, community healthcare volunteers, and the public[9]. Village health volunteers (VHVs) and community health workers are crucial for mobilizing populations, conducting screenings, and supporting preventive care. Furthermore, they act as liaisons in areas with limited healthcare resources[10]. Supported by digital innovations, their involvement can contribute substantially to the uptake and sustainability of NCD control initiatives in underserved communities[11]. However, high levels of user acceptability and satisfaction are critical for successful implementation. Recent research has confirmed a high level of user satisfaction and willingness to use digital NCD screening apps among various user groups, reinforcing the feasibility and effectiveness of technology-enhanced primary care[12,13].

Despite the increasing burden of NCDs, early detection and community-based risk assessment remain

limited, particularly in primary healthcare settings where screening tools are often paper-based or fragmented. There is a critical need for an accessible digital platform that can integrate risk assessment and educational feedback to empower individuals and strengthen health promotion efforts. Hence, the development and deployment of a web-based 'NCDs screening app', rooted in the PBRI model and leveraging interactive risk categorization and educational support, holds great promise for health promotion and early intervention. This is supported by emerging evidence that digital interventions can augment primary healthcare strategies and improve NCD outcomes at the community level[3,4,13]. Therefore, the present study aimed to: (1) develop a user-friendly screening application based on the PBRI model for the identification of individuals at risk for diabetes, hypertension, and depression; and (2) investigate the prevalence of these conditions among residents in Health Regions 1 and 2 using the developed application.

Material and Methods

This present study employed a research and development (R&D) methodology, consisting of two distinct phases: Phase 1: Application Development, and Phase 2: Prevalence Study (Figure 1).

Phase 1: Application development

The development of the "NCDs Screening App" followed the five steps of the PBRI model:

Step 1: Problem Identification and Analysis: During this step, a thorough review of the literature concerning the overall burden of diabetes, hypertension, and depression in Thailand, the challenges of current screening practices, and the potential of mHealth interventions was conducted. Existing clinical practice guidelines for these conditions in Thailand were also reviewed to ensure alignment of the application with national standards.

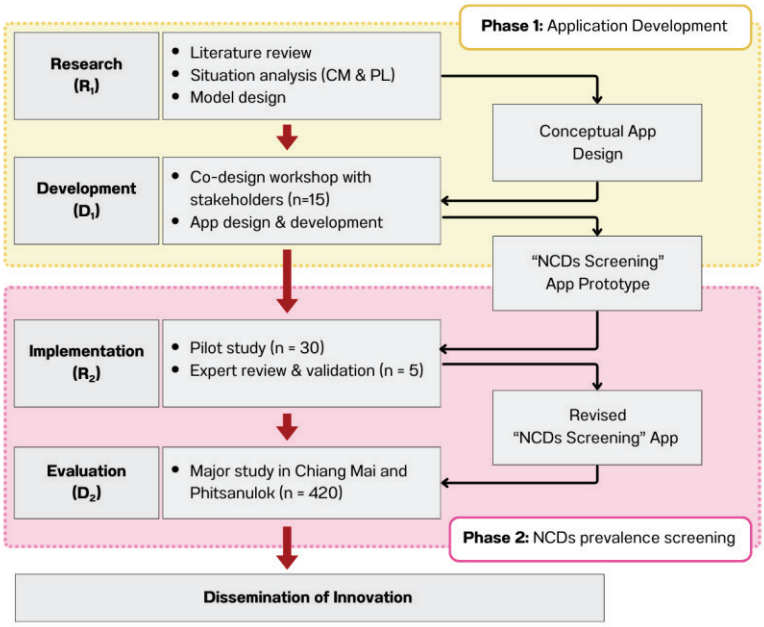


Figure 1 Research process

In Step 1 of Phase 1, we reviewed 15 publications focusing on diabetes, hypertension, and depression. This review utilized the Scopus and CINAHL Complete academic databases, as well as national guidelines from the Ministry of Public Health (MOPH), the Diabetes Association of Thailand, the Thai Hypertension Society, and the Department of Mental Health.

Step 2: Intervention Planning and Development: Based on problem analysis and literature reviews, a web-based screening application was designed with the following key features:

Risk Assessment Questionnaires: The application assesses diabetes, hypertension, and depression using context-specific indicators and culturally adapted tools. For diabetes, fasting blood sugar levels measured after at least 6–8 hours without oral intake, diagnosis status, and complications were recorded. Hypertension assessment included blood pressure measurements, diagnosis status, and complications. Depression was screened using 2Q, 9Q, and 8Q questionnaires, which are the standardized tools developed by the Department of Mental Health, Ministry of Public Health of Thailand.

Integration of Clinical Practice Guidelines: The application's algorithms for risk stratification and recommendations were directly based on Thailand's latest clinical practice guidelines for diabetes, hypertension, and depression.

The seven-color "traffic light" PBRI model for Risk Visualization: This user-friendly visual aid, adapted from existing health promotion models in Thailand, uses a seven-level color-code to represent the risk severity of each NCD, ranging from very low risk (e.g., white) to critical risk for illness (e.g., black).

Health Education Content: The application also features short, engaging educational videos and an easy-to-read manual, both developed in the Thai language and tailored for the local population. These materials provide essential information on risk factors, symptoms, prevention, and self-management of diabetes, hypertension, and depression.

Data Security and Privacy: Measures were implemented to ensure the security and privacy of user data, while adhering to relevant ethical guidelines and regulations.

User Interface Design: The application was designed with a user-friendly and intuitive interface, which is accessible to individuals with varying levels of digital literacy.

Step 3: Implementation: The developed application was deployed on a secure web server, accessible via web browsers available on both computers and mobile devices. Training materials and technical support were provided to the research team and potential users.

Step 4: expert evaluation and pilot testing:

Expert Evaluation: Five experts (a family physician, a psychiatrist, two nurses, and a technology specialist) were invited to evaluate the application using a uniform evaluation form. This form was structured around four key domains: content validity, technical functionality, usability, and adherence to clinical practice guidelines. To ensure consistent data collection and analysis, experts provided a rating for each item using a 5-point Likert scale with clearly defined anchors (e.g., 1 = 'Very Poor/Strongly Disagree' to 5 = 'Very Good/Strongly Agree').

Pilot Testing: A pilot test was conducted with thirty participants, selected by convenience sampling from the general population, to assess the usability and acceptability of the application, as well as user satisfaction. Participants completed NCD screening using the application and provided feedback through a structured questionnaire with a 5-point Likert scale.

Step 5: Refinement: Based on feedback received from expert evaluations and pilot testing, necessary revisions and improvements were made to the application with respect to content, functionality, and the user interface.

Phase 2: Prevalence study

Step 1: Participant Recruitment: The target population consisted of the residents of Mae Rim District, Chiang Mai Province (56,538 people) and Mueang District, Phitsanulok Province (139,405 people), totaling 195,943 individuals. The sample size was calculated using Krejcie & Morgan's formula[14]at a 95% confidence level and a ±5% margin of error, resulting in 384 participants. To account for potential non-responses, the sample size was increased by 10%, yielding a final total of 420 participants. The total sample was then distributed equally, with 210 participants (50%) selected from each of the two sites using a purposive sampling technique. This sample size represents approximately 0.37% of the target population in Mae Rim, Chiang Mai, and 0.15% of the target population in Mueang, Phitsanulok.

Step 2: Data Collection: Trained research assistants guided study participants through the screening process, using the refined "NCDs Screening App" on tablet devices. Participants answered risk assessment questionnaires for diabetes, hypertension, and depression. The application automatically calculated risk scores and categorized participants into different severity levels based on the seven-color "traffic light" PBRI model.

Step 3: Data Analysis: Descriptive statistics were used to analyze the prevalence of individuals identified at risk for each of the three NCDs. Frequencies and percentages were calculated for each risk category. As part of the prevalence study, overall user satisfaction with the application was also assessed using descriptive statistics based on the satisfaction questionnaires completed by the participants.

Ethical considerations

This study obtained ethical approval from the Ethics Committee of Boromarajonani College of Nursing, Chiang Mai (Approval No. BCNT08/2567). All participants in both phases provided written informed consent prior to participation. Written informed consent was obtained from all participants, who were informed of their right to withdraw from the study at any time without penalty. All collected data were anonymized to ensure confidentiality. The research was conducted in accordance with the Declaration of Helsinki and complied with all relevant institutional and national ethical standards.

Results

Development of the "NCDs Screening" Application

The "NCDs Screening" app was successfully developed as a web-based platform incorporating risk assessment questionnaires, integrated clinical practice guidelines, the seven-color "traffic light" PBRI model for risk visualization, and health education content in the Thai language for diabetes, hypertension, and depression risk assessment (Figure 2-4).

Expert Evaluation: An expert panel provided positive feedback on the content validity, technical functionality, and usability of the application, as well as adherence to clinical practice guidelines. Mean scores for all evaluation criteria were above 4.0 on a 5-point Likert scale, indicating a high level of agreement among the experts regarding the quality of the application.

Pilot Testing: The pilot test, based on thirty participants, demonstrated that the application has a high level of usability and acceptability. The overall mean satisfaction score was 4.56±0.19 on a 5-point Likert scale, with participants reporting that the application was easy to use, understand, and helpful.

The app's content was validated by five experts with an IOC ranging from 0.80 to 1.00. User satisfaction was evaluated using a structured questionnaire consisting of 10 items across three domains: (1) content (clarity of language, accuracy, usefulness, and reliability of information), (2) design (font readability, aesthetic appeal, and suitability for

target users), and (3) usability (ease of navigation, menu simplicity, and system stability). All items were rated on a 5-point Likert scale (1=Strongly Disagree to 5=Strongly Agree), and the survey concluded with an open-ended question for participants to provide specific suggestions for improvement. The app received high satisfaction scores across all evaluation phases. Experts (4.51±0.34), pilot users (4.56±0.19, and participants in the larger main study (4.34±0.41) rated the app highly, especially with respect to content accuracy and design clarity. App content was consistently ranked highest during the expert and pilot phases of the study, while app design received the highest score by users who participated in the main study. Usability was also rated positively across all groups. Some participants commented on limited accessibility due to internet dependence; therefore, the researchers provided supplementary booklets to ensure equal access to information for all participants.

Prevalence study

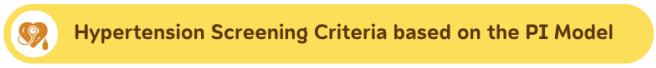
A total of 420 participants (mean age = 45.20±12.50 years; 62% female) from Health Region 1 (n=210) and Health Region 2 (n=210) completed the screening using the "NCDs Screening" Application.

Diabetes risk distribution analysis based on the results from the 420 main study participants from Health Regions 1 and 2 revealed that the majority were classified as low risk (white zone), with a higher proportion from Health Region 1 (72.38%) compared to Health Region 2 (38.57%). In contrast, a greater proportion of participants from Health Region 2 were identified as at-risk (pale green) at 30%, compared to 15.24% from Health Region 1. When combining both regions, 22.62% of participants were categorized as at-risk and 14.05% as partially controlled (yellow). Smaller proportions were classified as poorly controlled (orange, 4.52%) and severe (red, 3.33%). These findings suggest regional differences in risk profiles and highlight the utility of the seven-color classification model for identifying individuals at various stages of NCD risk and control (Figure 5).

Figure 2 Non-communicable diseases screening

Screening Criteria		FASTING BLOOD SUGAR (FBS)*/SYMPTOMS
White	Low risk	Fasting blood sugar < 100 mg/dL
Pale Green	At-risk	Fasting blood sugar = 100 - 125 mg/dL
Dark Green	Well-controlled	Fasting blood sugar < 125 mg/dL
Yellow	Partially-Controlled	Fasting blood sugar = 125 - 154 mg/dL, HbA1C < 7 mg%
Orange	Poorly-Controlled	Fasting blood sugar= 155 - 182 mg/dL HbA1C = 7.0 - 7.9 mg%
Red	Severe	Fasting blood sugar ⩾ 183 mg/dL, HbA1C ⩾ 8 mg%
Black	Complicated	Diabetes-related complications such as kidney disease, retinopathy, stroke/heart disease, or foot ulcers

**measured after a minimum of 6-8 hours without oral intake*



Screening Criteria		BLOOD PRESSURE (BP)/SYMPTOMS
White	Low risk	Blood Pressure < 120/80 mmHg
Pale Green	At-risk	Blood Pressure = 120 - 139/ 80 - 89 mmHg
Dark Green	Well-controlled	Blood Pressure < 139/89 mmHg
Yellow	Partially-Controlled	Blood Pressure = 140 - 159 / 90 - 99 mmHg
Orange	Poorly-Controlled	Blood Pressure = 160 - 179 / 100 - 109 mmHg
Red	Severe	Blood Pressure > 180/110 mmHg
Black	Complicated	Presence of hypertension-related complications such as heart disease, stroke, or kidney failure

Screening Criteria		SCORE		
		2Q	9Q	8Q
White	Low risk	0	-	-
Pale Green	At-risk	*	< 7	-
Dark Green	Mild Depression	*	7 - 12	-
Yellow	Moderate Depression	*	13 - 18	-
Orange	Severe Depression	*	> 18	1 - 8
Red	Moderate Suicide risk	*	> 18	9 - 16
Black	High Suicide risk	*	> 18	⩾ 17

**A positive response to at least one item on the 2Q questionnaire*

Figure 3 Infographic for diabetes, hypertension, and depression risk assessment based on the Praboromarajchanok model

Figure 4 Health education guide

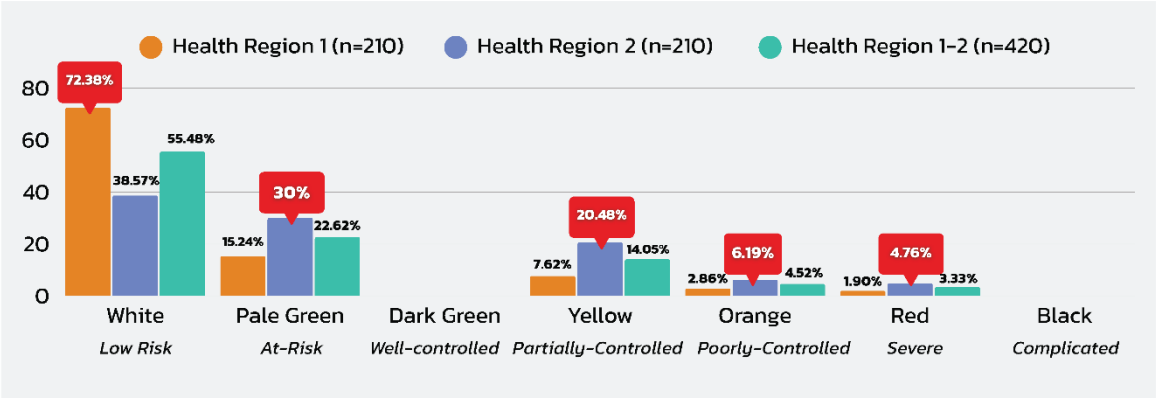


Figure 5 Diabetes prevalence in health regions 1 and 2 (n=420)

The distribution of hypertension risk levels among the main study participants is shown in Figure 6. The majority of participants from both regions were classified within the Pale Green (At-Risk) category, with a notably higher proportion from Health Region 1 (45.24%) compared to Region 2 (29.05%). The combined data show that overall, 37.14% of the study participants were at risk. However, a considerable number of participants were also classified in the White (Low Risk) group, including those from both Region 2 (13.81%) and Region 1 (22.38%), for a total of 18.10% overall. Conversely, only a small proportion of participants were classified as Dark Green (Well-Controlled) for this health category.

In terms of disease control, 22.38% of participants from Region 2 were categorized as Yellow (Partially Controlled), compared to 14.76% from Region 1. Similarly, 20.0% of Region 2 participants were placed in the Orange (Poorly Controlled) category, slightly higher than Region 1

(9.05%). With respect to the Red (Severe) risk category, participants from Region 2 had a higher proportion (14.76%) compared to Region 1 (8.57%), with an overall rate of 11.67%. The Black (Complicated) category was negligible across both regions. These findings suggest a high proportion of individuals at risk or with suboptimal control of NCDs, particularly those from Region 1, which had the largest proportion of individuals classified as at-risk (Pale Green).

The majority of the main study participants from both regions were classified as low risk for depression (White zone), with 57.62% from Health Region 1 and 58.33% from Health Region 2. When combined, 59.05% of all main study participants were categorized in the low-risk category. In the at-risk group (Pale Green zone), 30.48% of participants from Health Region 1 and 34.29% from Health Region 2 were identified, accounting for 32.38% overall. For mild depression (Dark Green zone), 10.95% of individuals from Region 1 and 6.19% from Region 2 were identified as affected, representing 8.57% across both regions. Moderate depression (Yellow zone) was reported for 0.95% of study participants from Region 1 and 0.48% from Region 2, totaling 0.71% overall. No cases were found to correspond to the Orange (severe depression), Red (moderate suicide risk), or Black (high suicide risk) zones. These results suggest that while a majority of the population is at low risk, approximately one-third exhibit elevated risk or early signs of depressive symptoms, warranting further monitoring and early intervention efforts (Figure 7).

Similar to the pilot study, the prevalence study, overall user satisfaction with the application was also high, with a mean score of 4.34±0.41 on the 5-point Likert scale. Participants of the main study found the application to be user-friendly, informative, and a convenient way to assess their risk for NCDs.

Discussion

The present study describes the successful development, evaluation, and validation of an "NCDs Screening" app for the early detection of diabetes, hypertension, and depression risks in primary care settings in Thailand. The high ratings given by the expert evaluators and pilot study participants indicate that the application is reliable, usable, and user-friendly. This overall satisfaction

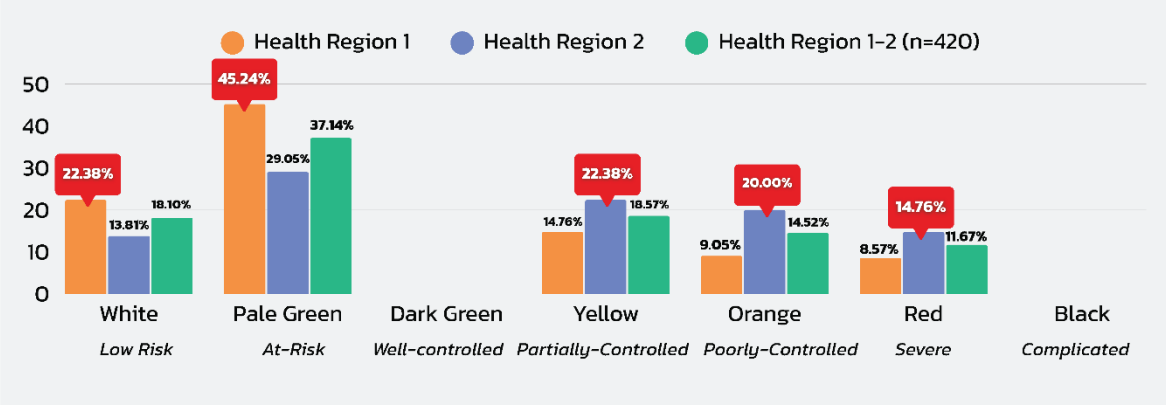


Figure 6 Hypertension prevalence in health regions 1 and 2 (n=420)

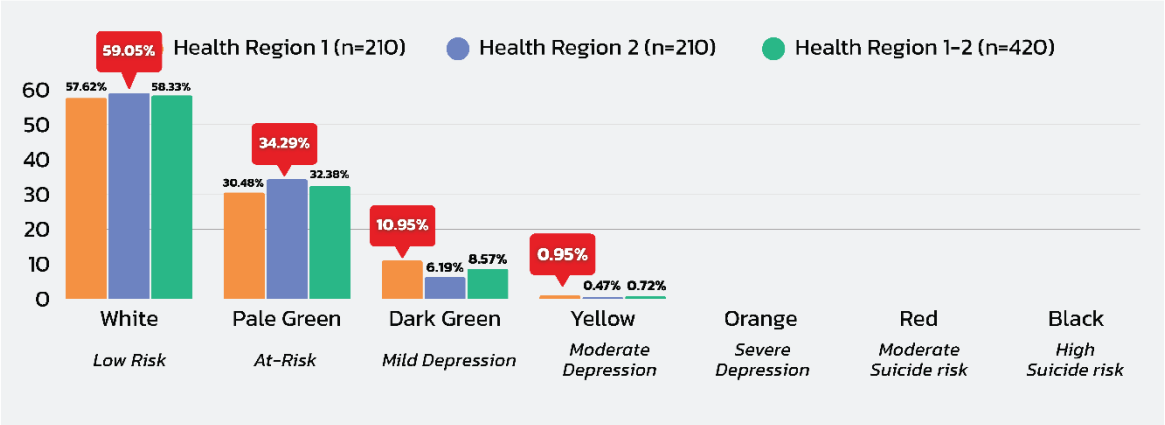


Figure 7 Depression prevalence in health regions 1 and 2 (n=420)

reported by the evaluators and study participants is important because prior research suggests that usability and perceived usefulness are critical for the sustained adoption of digital health tools in community health contexts[3,14,15].

Incorporation of the seven-color "traffic light" PBRI model in the application enabled effective stratification of study participants according to risk levels, enhancing understanding and facilitating targeted interventions. This approach is in agreement with the previous findings that the use of a color-coded risk classification system can improve comprehension and health literacy among users, especially in low-resource settings[5]. The integration of educational videos and user manuals further supports behavioral changes, a core element of the PBRI framework, fostering informed self-care and timely referral[16-18].

The prevalence findings obtained in the present study demonstrate that a substantial proportion of individuals are at 'pale green' risk or higher for hypertension (37.14%), depression (32.38%), and diabetes (22.62%), confirming that the risk for NCDs remains a significant public health challenge in the surveyed communities. The variation in results observed between Health Regions 1 and 2 underscores the utility of digital tools in identifying spatial disparities and tailoring community-specific interventions. Similar regional differences have been noted in prior epidemiological studies, emphasizing the importance of localized screening strategies[1,19].

The findings highlighted diabetes' dual burden of risk and poor control. Our finding that 22.62% of participants were "at-risk" (Pale Green) supports global prediabetes incidence estimates, indicating a large pre-clinical population needing early intervention[20]. The cohort was 35% "partially controlled" (20.50%) or "complicated" (3%). This data supports previous results that up to 56% of type 2 diabetics fail to control their blood sugar[21]. This screening model effectively stratifies the large "at-risk" cohort from the "well-controlled" (22.60%) and "uncontrolled" groups, identifying target populations for public health interventions like primary prevention and enhanced clinical management.

Our hypertension risk profile is alarming, with a large "at-risk" population (37.14%) and poor disease treatment rates. Recent broad national surveys show that more than one-third of people worldwide have prehypertension, which matches the "Pale Green" (At-Risk) group's

prevalence[22]. A "minor fraction" of individuals were "Dark Green" (Well-Controlled), whereas 11.67% were "Severe" (Red). This raises concerns about sickness management. This poor control rate signals the global hypertension pandemic. The World Health Organization[23] reports that 1.3 billion people have hypertension, but only 21% manage it properly. Our findings show the widespread insufficiency in illness management and the usefulness of this screening technique in identifying and classifying the large, high-risk, uncontrolled population for timely treatment.

The depression screening findings showed a 59.05% "Low Risk" (White) population. Public health is especially concerned with the substantial segment with sub-clinical or moderate symptoms: 32.38% of the cohort was "at-risk" (Pale Green) and 8.57% had "mild depression" (Dark Green). This large 40.95% group, while not extremely unwell, has a greater risk of a major depressive episode[24]. Compared to population studies, which reveal a high incidence of moderate-to-severe symptoms, severe instances were rare (0.7% intermediate and 0% severe/suicide risk)[25]. This contrast shows our screening strategy identified substantial, often-overlooked sub-clinical and mild-symptom groups, revealing an optimum window for targeted, preventative mental health treatments rather than acute clinical care.

However, the present study also had limitations, including a relatively modest sample size and potential selection bias inherent to voluntary participation. Further research is recommended to assess the longitudinal impact of the NCDs screening application on health outcomes, adherence to recommendations, and scalability across diverse settings. Moreover, integration of real-time clinical decision support and linkage to healthcare facilities could enhance the app's effectiveness in managing the above-identified risks[26-28].

Conclusion

The "NCDs Screening" app demonstrates significant promise as a scalable, participatory digital health solution for multiplex NCDs risk assessment and education in primary care settings. Its design promotes community engagement and supports VHVs, addressing the critical gaps in early detection and health promotion identified previously in the literature. Results from the present study contribute to a growing body of evidence supporting innovative digital interventions to mitigate the rising burden of NCDs globally.

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Conflict of interest

There are no potential conflicts of interest to declare.

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