Comparison between "Rokprachamtua Khong Chan (My Underlying Diseases)" Web Application and Human-based Conventional Method to Stratify Military Personnel's Health Status and Report Results Effectively

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Abstract:

Background: Fort Nawamintharachini hospital developed the "5 colors ball tool" innovation to promote health concerns among military personnel after health checkups. However, this process resulted in time consumption, a high misdiagnosis rate, resource waste, expenses, and healthcare worker burnout. Consequently, a web application was developed to automate health checkup stratification and reporting.

Objective: The aim of this study is to evaluate the effectiveness of the "Rokprachamtua Khong Chan" web application in stratifying and reporting health results compared to human based conventional method.

Methods: This is an observational study which sampled 130 checkup results from 2,285 health results of military personnel who underwent medical checkups with Fort Nawamintharachini Hospital in 2023. The study compared misdiagnosis rate of web application with human-based process by using the same health results and stratified by specialist as a gold standard. Furthermore, the study also measured the time to report heath results.

Results: 2,285 checkup results were stratified into the following groups: green group 510 (22.32%), yellow group 482 (21.09%), orange group 759 (33.22%), pink group 232 (10.15%), and red group 302 (13.22%). The misdiagnosis rate of web application was lower than human-based conventional method which were 5.38% and 10.77% respectively (p=0.05). The web application reduced the time it took to stratify and report results from three months to seven days.

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Conclusion: The "Rokprachamtua Khong Chan" web application is a useful tool that utilizes computer-based processing and technology to stratify the health status of military personnel. The application offers several advantages, including preventing human error, shortening the time required to report health results, and streamlining the process.

Keywords: Web application, Stratification, Checkup results, Effectiveness, Military personnel

Introduction

Fort Nawamintharachini Hospital is a military secondary care unit that offers health promotion, health prevention, and medical care to military personnel and their families. One of our services is an annual health checkup. To promote health concern in military service members, we created the "5 Colors Ball Tool," which is adapted from the "7 Colors Ball Tool" that contributes to health concern, severity perception, and leads to positive behavioral change.[1,2] Our 5 Colors Ball comprises green for good health, yellow for an increased chance of developing a disease, orange for a possible new diagnosis, pink for a well-controlled status of chronic diseases, which consist of hypertension, diabetes, or hyperlipidemia, and red for a poorly controlled status of chronic diseases.

The workflow of health checkup consisted of the following steps: (1) Military personnel underwent medical history taking, blood pressure measurement, weight and height assessment, waist circumference measurement, chest X-ray, and blood sample collection. (2) All checkup results were printed. (3) Two nurses stratified checkup results into the 5 colors groups. (4) Nurses sent checkup reports to military personnel in each military unit and provided advice.

After using the 5 Colors Ball Tool, we expected a decrease in the number of military personnel in the orange and red groups. However, we found that the number of personnel in the orange group increased from 14.45% in 2021 to 15.46% in 2022. Moreover, we encountered several issues,

including a misdiagnosed rate of 18.75%, lengthy reporting period which took three months to send health reports, loss of documents, waste of time and resources, and healthcare worker burnout.

Nowadays, technologies have been developed so far that healthcare professionals apply technology devices and applications for many purposes. It has been revealed that technology provides many benefits, such as a lower error rate, a rapid process, improved quality of data management and accessibility, and, most importantly, a positive effect on patient care outcomes.[3-7] Therefore, Fort Nawamintharachini Hospital decided to create an application that stratifies and reports results automatically with effectively, which was measured by reducing misdiagnosed rate and shorten the time to report health results.

Methods

In 2022, we developed a web application called "Rokprachamtua Khong Chan," which we first implemented in the recent health checkup from January to March 2023. Military personnel can access their checkup results through various devices, such as mobile phones, computers, laptops, and iPads.

Workflow

In 2023, a total of 2,285 military personnel underwent health checkups. Their data, which included blood pressure (BP), body mass index (BMI), waist circumference, blood test results, urine test results, stool test results, and ICD10-

diagnosis codes, were used to categorize them into five colors, which were then displayed in the web application alongside their lab results, medical information, and health advice. Those who were categorized as orange were appointed by the nurse for medical treatment, and the appointment date was displayed in the web application. The new workflow process is shown in Figure 1.
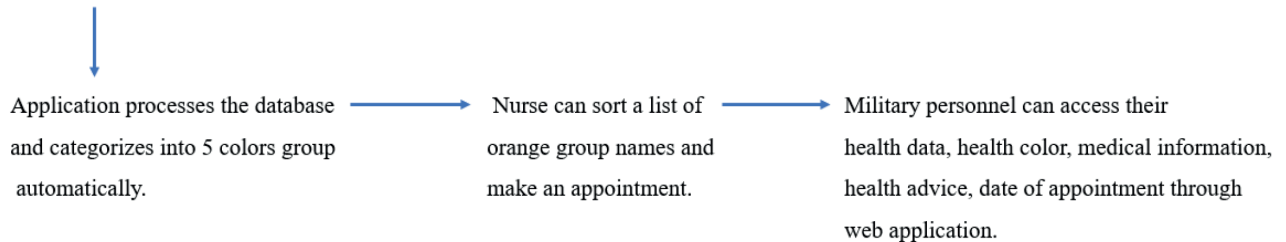

Figure 1 Workflow of health checkup with "Rokprachamtua Khong Chan" web application

User Interface

We developed a user-friendly interface (Figure 2) in the web application.[8-11] To log in, users need to fill in their ID number and password, which they created during registration. The application provides various functions, such as displaying personal data, health status, health colors, medical illnesses, medications, laboratory results, referral documents, appointment dates, medical information, and health advice. Moreover, a supportive channel was created for users to change their appointment date or inquire about their health through Line Official Account.
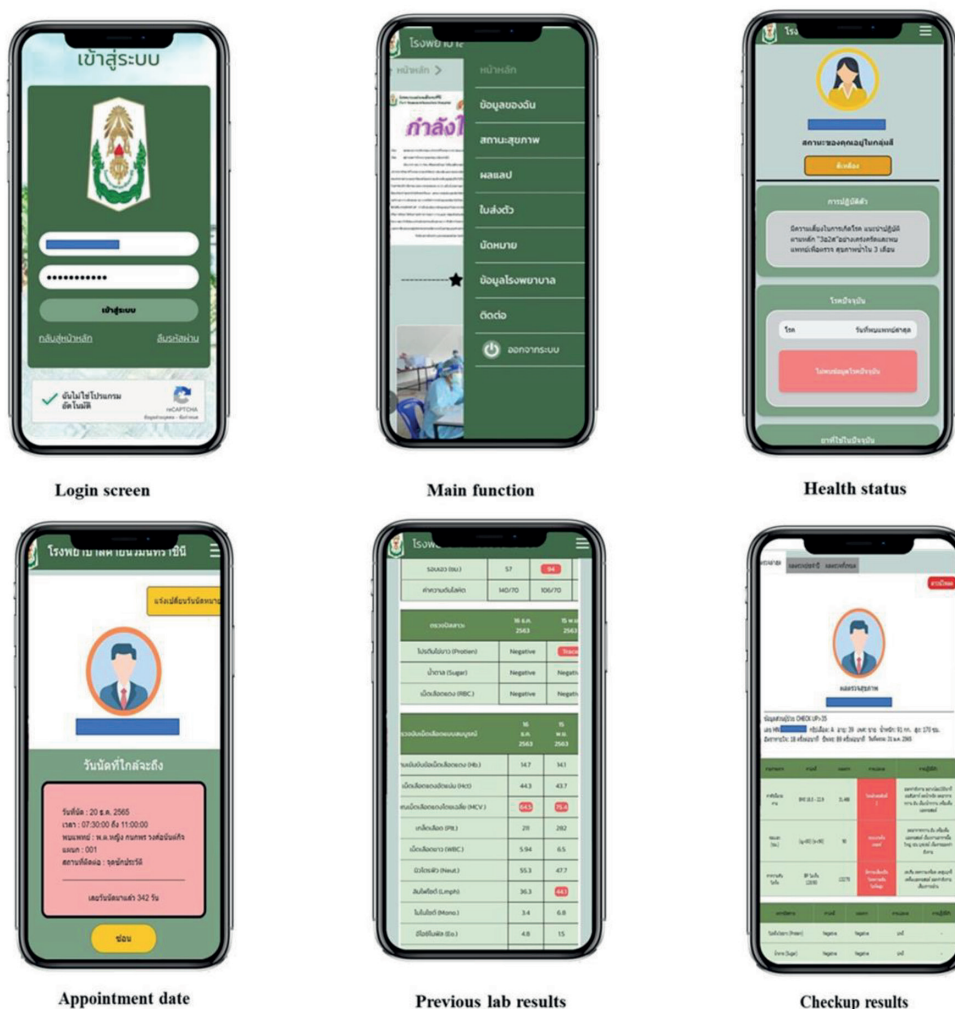
Figure 2 User interface

Apart from the user interface, the nurse interface can monitor users in each group and track those in the orange and red groups for treatment.

Stratification Algorithm

The "Rokprachamtua Khong Chan" web application categorizes health checkup results into five color-coded groups (Table 1) to identify health concerns and promote positive behaviors for preventing noncommunicable diseases (NCDs), which are the leading cause of death in Thailand.[12] The green group represents healthy individuals with blood pressure (BP) < 120/80 mmHg, body mass index (BMI) < 23 kg/m^2, waist circumference < 80 cm (female) or < 90 cm (male), and all laboratory results within the normal range. The yellow group represents individuals at risk with one or more of the following: BP 120-139/80-89 mmHg, BMI 23-39 kg/m^2, waist circumference ≥ 80 cm (female) or ≥ 90 cm (male), fasting blood sugar 100-125 mg/dL, serum uric acid > 8.4 mg/dL. The orange group represents individuals with suspected disease, with one or more of the following: BP ≥ 140/90 mmHg, BMI ≥ 40 kg/m^2, fasting blood sugar ≥ 126 mg/dL, serum cholesterol > 200 mg/dL, serum triglyceride > 150 mg/dL, etc. The pink and red groups are identified using ICD-10 codes. Users diagnosed with ICD-10 codes I10, E10, E11, or E78 are categorized as either pink or red. Users with I10 recorded with BP ≥ 140/90 mmHg, E10 or E11 recorded with fasting blood sugar ≥ 130 mg/dL, or E78 recorded with serum cholesterol ≥ 200 mg/dL or serum triglyceride ≥ 150

mg/dL, are categorized as red. Users who do not meet these criteria are categorized as pink (Figure 3). Our algorithm is based on guidelines from sources such as the Division of Non-Communicable Diseases, WHO criteria for diagnosing polycythemia vera, The Thai Society of Hematology, etc.

Table 1 Criteria for risk stratification

		Green	Yellow	Orange	Red	Pink
Blood pressure (mmHg)	Systolic	< 120	120 - 139	≥ 140	≥ 140	
	Diastolic	< 80	80 - 89	≥ 90	≥ 90	
Heart rate (bpm)				<50, >120		
Body mass index (kg/m²)		< 23	≥ 23 - < 40	≥ 40		
Waist circumference (cm)	Female	< 80	≥ 80			
	Male	< 90	≥ 90			
Fasting blood sugar (mg/dL)		< 100	100 – 125	≥ 126	≥ 130	
Hb (g/dL)	Male	13-16.5		<13, > 16.5		
	Female	12-16		<12, > 16		
Hct (%)	Male	39-49		<39, > 49		
	Female	36-48		<36, > 48		
Platelet (10³cell/cu.mm.)		140-400		<140, > 450		
WBC (10³cell/cu.mm.)		4-11		< 4, > 11		
Uric acid (mg/dL)		2.47-8.4	> 8.4			
BUN (mg/dL)		6-20		> 20		
Creatinine (mg/dL)		0.5-1.2		> 1.2		
eGFR (ml/min/1.73mm³)		> 90		< 60		
Cholesterol (mg/dL)		≤ 200		> 200	≥ 200	
Triglyceride (mg/dL)		≤ 150		> 150	≥ 150	
SGOT /AST(U/L)		0-37		>37		
SGPT/ALT (U/L)		0-41		> 41		
Alkaline phosphatase (U/L)		40-129		> 129		
Stool occult blood				positive		
Urine				Sugar1+, RBC 1+, Protein 1+		

Application Security

During the development of this application, cybersecurity policies were a top priority, especially when handling medical data. We designed the application to restrict access to healthcare workers and only permitted authorized personnel to access the data. Users are required to register with the application manager before using the program, and the user's details must be
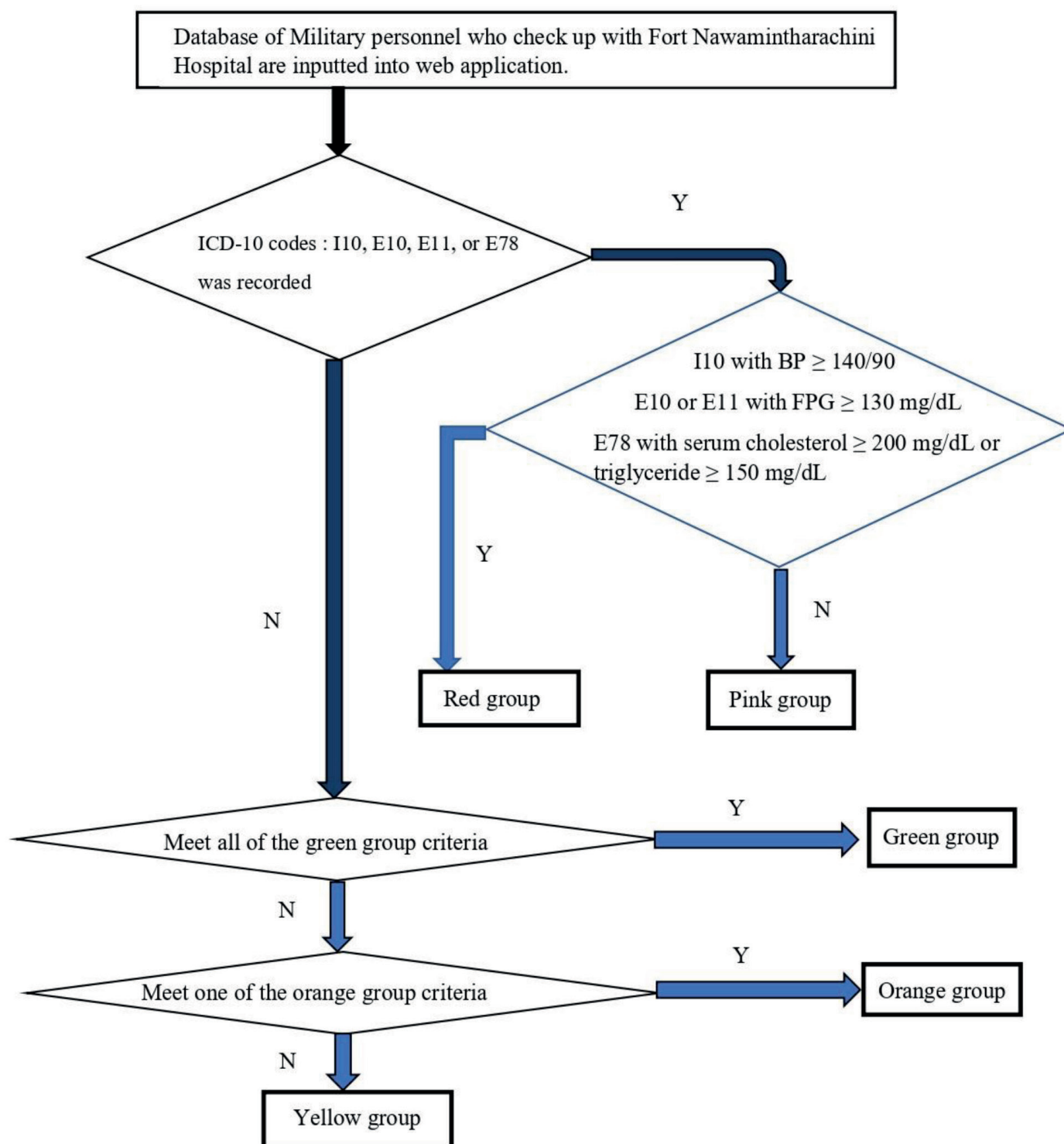

Figure 3 Workflow of algorithm stratification

registered and identified in the hospital's database before being granted access. Moreover, if the user remains inactive for 15 minutes, the application will log out automatically. According to the Personal Data Protection Act (2019), users must be informed of the purpose of collecting, using, or disclosing their Personal Data and be requested to provide their consent before starting to use the application.

Because it's a pilot study, authors calculated sample size from the misdiagnosed data in 2022 which was 9 misdiagnosed results from the sampling of 48 results (18.75%). The calculated sample size was 40. The authors sampled 130 results from the health reports of 2,285 military personnel who underwent health checkups with Fort Nawamintharachini Hospital in 2023 by simple randomization and compared misdiagnosed rate of web application stratification with nurse stratification.

Results

In 2023, 2,285 military personnel underwent medical checkups, all of them were male. The average age was approximately 33 years and ranged from 20 to 58 years. All 2,285 health reports were stratified into five color groups: green (510, 22.32%), yellow (482, 21.09%), orange (759, 33.22%), pink (232, 10.15%), and red (302, 13.22%). The misdiagnosed rate in the stratification process using the web application was 5.38% compare with nurse stratification was 10.77% ($p = 0.05$) as shown in Figure 4. The application reduced the time to stratify and report results from three months to seven days. The Lean process also reduced costs of transportation, paper, ink which were 23,220 baht, more importantly, web application saved 462 hours of nurse working hours, reduced nurse workload, and prevented burnout in healthcare professionals.
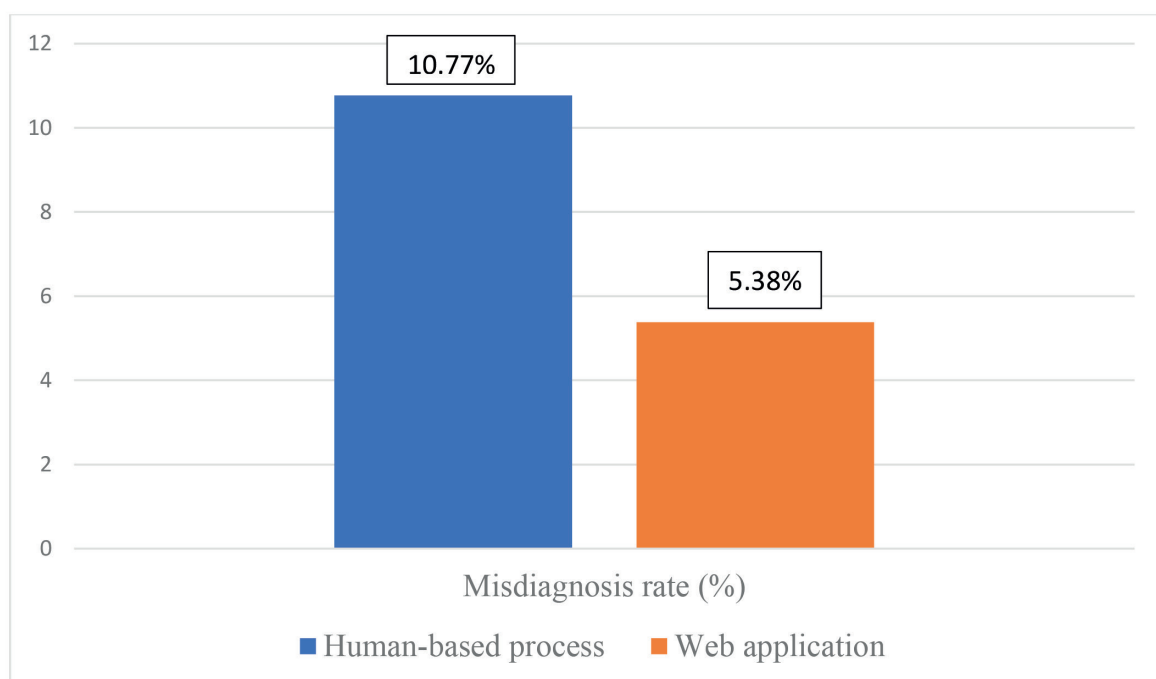

Figure 4 Comparison the misdiagnosis rate of stratification between human-based process and web application

Discussion

The "Rokprachamtua Khong Chan" application is the first application in Thailand that uses color to stratify checkup results for promoting health concern in military personnel. Using colors will contribute to visual perception, perceived severity, health motivation leading to positive behavioral change according to the concept of the health belief model theory. Previous studies[1,2,4] have also shown the effectiveness of reduction in disease severity with the provision of health behavior modification programs. The study in Bangladesh[4] also suggested that using both technology and color stratification in health checkups is an effective tool in the social healthcare system in developing countries.

Because the military unit in Chachoengsao province was transferred to take responsibilities by Fort Chakrapong Hospital, the number of military personnel who had checkups with Fort Nawamintharachini Hospital declined in 2023. The number of military personnel in the orange group increased from 15.46% in 2022 to 33.22% in 2023 because the stratification criteria were defined more specifically, such as hemoglobin of male < 13 mg/dL, creatinine > 1.2 mg/dL, instead of the "lab abnormality" in previous criteria, which we can't ensure that sorter used all laboratory results to determine. As well as, we interviewed nurses who stratified checkup results, they said that sometimes they used their opinions to stratify colors. If the lab was slight abnormality like AST 40 mg/dL, they didn't stratify to orange group. Furthermore, the stratification with the web application is more effective than human, as it is more precise, accurate, and faster, which is demonstrated by the lessened misdiagnosed rate and the shortened time to stratify and report. Besides, web application has a channel for military personnel to ask about their health problems and healthcare workers gives recommendations such as exercise, healthy dietary pattern, and individual lifestyle counseling. The authors identified the cause of misdiagnosed rate and found that one of problems was inadequate input of ICD-10 diagnosed history data. Therefore, data of ICD-10 diagnosed history for at least 5 years were inputted to solve this problem. Moreover, some health information such as blood pressure, heart rate, BMI, waist circumference must be filled by healthcare workers which can cause human error and lead to the wrong stratification.

There were some limitations in the process of health checkup. Firstly, there was still a human process such as filling in the data about BMI, waist circumference, and vital signs because there was no automatic machine. Secondly, limited resources both in healthcare workers and medical equipment caused screening hustle. The healthcare workers had to screen about 120-300 military personnel per day, so sometimes there was not enough time to repeat blood pressure measurement which might affect the blood pressure result.

The authors plan to create health behavior modification interventions that are specified in each group and measure the health outcomes. We not only want to survey user satisfaction to improve the application but also want to validate our stratification algorithm and create the best version to maximize health benefits. Furthermore, we want to use the data to create projects and determine the hospital policy for improving the process of care in military personnel and their families.

Conclusion

The "Rokprachamtua Khong Chan" application is a helpful web application that categorizes the checkup results of military personnel into five color groups to raise health concerns. We used computer-based processing and technology to avoid human

error, shorten the time to report health results, use a Lean process, prevent document loss, facilitate two-way communication, and proactively care for military personnel.

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