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Original Article

Digitalization of HYPOGLYRISK and Evaluation of Its Utility for Pharmacist-Led Hypoglycemia Risk Assessment in Type 2 Diabetes Mellitus

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Abstract

Background: We developed a tool for pharmacists to facilitate screening of medication-related hypoglycemia risk in patients with type 2 diabetes mellitus (T2DM), called HYPOGLYRISK. Although this instrument has been validated and proven reliable, the paper-based version was considered inefficient and prone to human error during routine screening.

Objective: This study aimed to digitalize HYPOGLYRISK and evaluate its utility compared with the printed version.

Methods: A mixed-method study design combining software development and a quasi-experimental trial was used. In the development stage, the application was created using Android Studio and validated through Black Box Testing and User Acceptance Testing (UAT). In the trial stage, 46 pharmacists participated and were divided into two groups using either the digital or paper-based HYPOGLYRISK to assess simulated ambulatory T2DM patients representing different hypoglycemia risk categories. The primary outcome was assessment time efficiency, while the secondary outcome was the potential for human error. Data were analyzed using the Mann-Whitney U test, chi-square test, and relative risk analysis.

Results: The digital HYPOGLYRISK demonstrated significantly shorter assessment time compared with the conventional version ($p<0.05$) and reduced the probability of scoring errors by 3.3 times ($p<0.05$). The digital application also provided additional advantages, including efficiency, scalability, ease of use, rapid data access, and simplified data management.

Conclusion: These findings suggest that digital HYPOGLYRISK can enhance pharmacist-led hypoglycemia risk assessment among ambulatory patients with T2DM.

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INTRODUCTION

Severe hypoglycemia is one of the most important medication-related safety issues among patients with type 2 diabetes mellitus (T2DM). Hypoglycemia events may lead to serious clinical consequences, including hospitalization, cardiovascular complications, cognitive impairment, and increased mortality risk.[1,2] In ambulatory diabetes care, the risk of hypoglycemia is often associated with antidiabetic therapy such as insulin or sulfonylureas, inappropriate medication use, and patient-related risk factors.[3,4] Therefore, early identification of patients at high risk of hypoglycemia is an essential component of medication safety strategies in diabetes management.

In recent years, digital health technologies have been increasingly implemented to improve medication safety and clinical decision-making. Mobile health applications and digital clinical tools have shown potential in supporting healthcare professionals in patient monitoring, risk assessment, and clinical documentation. Digitalization of clinical assessment tools may improve efficiency, minimize human error, facilitate data management, and enhance accessibility during routine healthcare services.[5,6] However, despite the rapid development of digital health solutions, validated mobile tools specifically designed for hypoglycemia risk screening in ambulatory T2DM patients remain limited.

In our previous studies, we have created a tool for pharmacists to facilitate the screening of medication-related severe hypoglycemia risk in ambulatory patients with Type 2 Diabetes Mellitus (T2DM), named HYPOGLYRISK (Medication Related Hypoglycemia Risk Score Assessment Tools).[7–10] HYPOGLYRISK was synthesized through systematic studies, FGD, and psychometric properties through content validity, criterion validity, construct validity, face validity,

and reliability test. All stages have been passed and declared valid and reliable. The pharmacist's deployment of HYPOGLYRISK revealed issues with limited patient screening duration. In addition, the use of paper-based HYPOGLYRISK in screening T2DM patients is often impractical and prone to human error, and there were problems in archiving documents of the assessment results.[7–10]

However, the implementation of the paper-based HYPOGLYRISK instrument revealed several practical limitations in routine clinical practice. Several reported studies recommend digitizing a paper-based instrument, such as Medical Health Records (HR), to Electronic Medical Records (EHRs) to gain several benefits, such as improved accessibility, enhanced efficiency, enhanced security, better data management, improved patient care, data backup and disaster recovery, and reduced costs.[11–15] The HYPOGLYRISK assessment output is part of the information in the medical record. In this case, the pharmacist who has screened the patient with this instrument contains the patient's confidential information. The output in HYPOGLYRISK must be treated similarly to the patient's medical record information.

To overcome the problem of the printed version HYPOGLYRISK, digitizing it is necessary. The implementation of this instrument is carried out by pharmacists who work in outpatient pharmacy installations and is intended for T2DM ambulatory patients. The results of the needs assessment on pharmacists as users of the instrument show that the application is required to be able to operate practically and can be carried anywhere by pharmacists. The software can run lightly on portable devices, does not require a continuous internet connection, and the data integration process with EHRs can be done easily. Based on these conditions, the right software for them is directed at applications on Android-based smartphones that work locally. Android apps were chosen because the majority of smartphones and mobile devices circulating in Indonesia have the Android operating system.[16–19]

This study aims to remake HYPOGLYRISK into a digital form (Android Apps) to evaluate its utility compared to the printed version for pharmacists in hypoglycemia screening activities. The main expectation in this study was that the application could help the main problem of pharmacists, namely, the efficiency of patient risk assessment time.[20] The next prospect was that the application developed could provide practicality, zero error in assessment, data access, data management, and data integration of patient data to EHRs more conveniently.

METHODS

This study adopted a mixed method between software development and a trial. In general, this study includes two stages. The first stage was the software development and validation stage. The second stage was the software trial by pharmacists as software users to simulate ambulatory T2DM patients.

Software Development

The HYPOGLYRISK mobile application interface was developed in the Indonesian language, as the intended users of the application were pharmacists practicing in Indonesia. The application was built using Android Studio and designed to operate on Android-based smartphones. The application functionalities were derived directly from the previously validated HYPOGLYRISK instrument, including patient data entry, risk factor assessment, automated score calculation, and risk categorization. Additional utility features, such as screening history, application user guide, and patient education materials, were incorporated to support pharmacists' workflow during screening activities. The development process involved collaboration between the clinical research team and an informatics specialist responsible for application coding, software architecture, and user interface design. The software development and validation stages were conducted prior to the trial phase, while the application trial involving pharmacists was carried out in August 2024 at UNUD Hospital, Bali, Indonesia.

Software Validation

1. Participants and Sample Size

The research participants were all pharmacists practicing at Universitas Udayana (UNUD) Hospital, Bali, Indonesia, and surrounding health facilities, and they met the following research criteria. 1) Inclusion Criteria: a) Pharmacists have experience practicing in health service facilities such as hospitals, community public health centers, community pharmacies, and primary private clinics; b) Pharmacists have served patients with diabetes mellitus who returned home with antidiabetic agents. 2) Exclusion Criteria: a) Pharmacists were not willing to be involved in research; and b) Pharmacists have responsibilities in service and pharmaceutical supply management at the same time. All research subjects can only become samples/respondents in the research if they have understood and signed the informed consent prepared by the researcher. Pharmacists were recruited using a purposive sampling approach based on the predefined eligibility criteria. No minimum number of years of professional experience was specified as an

inclusion criterion; however, participants were required to have experience providing pharmaceutical services to patients with diabetes mellitus. Pharmacists' professional experience was recorded as part of baseline characteristics and analyzed to assess comparability between study groups.

The sample size estimation differed according to the objective of each study phase. The validation phase applied a correlational analysis approach to determine the minimum number of participants required for system testing. The sample size calculation uses a numerical correlational analysis type with the following equation (1).

$$n = \left[\frac{(Z_{\alpha} + Z_{\beta})}{0.5 \ln\left(\frac{1+r}{1-r}\right)}\right]^2 + 3 \quad \text{..... (1)}$$

Formula description:

n: Number of subjects
α: Type one error (set at 5%)
β: Type two error (set at 10%)
Zα: Standard alpha value (1.64) for one-way hypothesis
Zβ: Standard beta value (1.28)
r: Minimum coefficient considered significant (set at 0.5)

Based on equation (1), the calculation of the minimum number of samples required is as follows.

$$n = \left[\frac{(1.64 + 1.28)}{0.5 \ln\left(\frac{1+0.5}{1-0.5}\right)}\right]^2 + 3 = 32 \; pharmacist$$

The minimum number of participants required was 32 pharmacists. In practice, a total of 46 pharmacists participated in both the software validation and trial stages. The larger sample size increased the statistical precision of the study and reduced the potential sampling error, thereby strengthening the reliability of the findings. This larger sample size also reduces the probability of Type II error compared with the minimum required sample size.

2. Black Box Test

Black box validation is a descriptive validation. A black box test was conducted by asking pharmacists to try all the menus and features available on the developed apps on their respective devices.[21] Participants were given a printed form containing a checklist of menus that must be tried. Pharmacists fill in information in the form of check marks if the menu runs well on their devices. If there was a problem in running the menus in the black box list, participants could fill in their problem in a description box provided on the form.

3. User Acceptance Test

User Acceptance Test (UAT) is a process to determine whether the system (prototype) developed is in accordance with user needs or not. This test was conducted after pharmacists went through the app trial stage. There were 10 standard statements in the UAT questionnaire adopted to be answered by users, in this case, pharmacists, according to their respective perceptions.[22] The sentences in the statements were adjusted to the system/application that was in accordance with the digital HYPOGLYRISK being developed. All pharmacists involved in this study provided their perceptions on a Likert scale with a range of 1-4. The scale order was stated as follows: Strongly Disagree point 1, Disagree point 2, Agree point 3, and Strongly Agree point 4. This scale applies to every positive statement. Negative questions apply the opposite, where Strongly Disagree is point 4, Disagree is point 3, Agree is point 2, and Strongly Agree is point 1.

4. Data Presentation and Analysis

Black box validation data is presented descriptively by presenting a table of the proportion distribution of menu items and functions running on the pharmacist's device as a user. In the UAT analysis, questionnaire items with a Likert scale were analyzed using the average of each positive and negative sentence with a total score in the range (0-100) interpretation as follows: Grade A: Very Good: Score >80.3; Grade B: Good: Score 68 - 80.3; Grade C: Sufficient: Score 68; Grade D: Poor: Score 51-68; Grade F: Very Poor: Score <51. The results of the UAT data analysis were displayed in tabular form.[21,22]

Software Trial

1. Study Design and Setting

The study design at this stage was quasi-experimental, where pharmacists were divided into two groups: the trial group, which used the digital HYPOGLYRISK, and the control group, which used the printed version of the HYPOGLYRISK. This trial was conducted at UNUD Hospital, Bali, Indonesia, in August 2024.

2. Participants

The research participants were all pharmacists practicing at UNUD Hospital and surrounding health facilities, and met the following research criteria. 1) Inclusion Criteria: a) Pharmacists have experience practicing in health service facilities such as hospitals, community health centers, community pharmacies, and private primary clinics; b) Pharmacists have served patients with diabetes mellitus who returned home with antidiabetic agents. 2) Exclusion Criteria: a) Pharmacists were not willing to be involved in research; and b) Pharmacists have responsibilities in service and pharmaceutical supply management at the same time. All research subjects can only become samples/respondents in the research if they have understood and signed the informed consent prepared by the researcher. Some pharmacists involved in the validation stage were recruited from the same professional population as those participating in the trial phase. However, the validation stage focused on application functionality testing, whereas the trial stage evaluated the practical utility of the application in simulated patient screening scenarios.

In addition to pharmacists, T2DM patients were also part of the participants in this study. For ethical reasons, during the software trial, we used simulated patients taken from real T2DM patients. A total of three T2DM patients were invited to participate in the study. These three patients represent low, moderate, and high risk of hypoglycemia, respectively.

3. Trial Form

The trial form in the context of this study was ambulatory T2DM patients who were assessed by pharmacists using HYPOGLYRISK digital. The three patients were assessed alternately by pharmacists in both groups using either the application or conventional (paper-based) methods.

4. Trial Outcome

The primary outcome measured was the comparison of the duration of assessment in both groups. At the same time, the secondary outcomes measured were the potential for human error in conducting the patient assessment, user adaptability, interactiveness, rapid data access, simple data management, and practicality of data integration.

5. Sample Size

The sample size estimation differed according to the objective of each study phase. The trial phase used a comparative sample size formula for two independent groups. The sample size approach used was the unpaired two-group, one-measurement numerical comparative formula as follows (2).

$$n1 = n2 = 2\left(\frac{[Z\propto + Z\beta]\ S}{x1-x2}\right)^2 \quad \text{..... (2)}$$

Formula description:

n1: Number of subjects in the digital HYPOGLYRISK group.
n2: Number of subjects in the conventional HYPOGLYRISK group.
α: Type one error (set at 5%).
β: Type two error (set at 20%).
Zα: Standard alpha value (1.64) of the two-way hypothesis.
Zβ: Standard beta value 10% (1.28).
S: Combined standard deviation of both groups of literature (set at 5 minutes).
x1-x2: Minimum mean difference of both groups (researcher's judgment set at 5 minutes).

Based on formula (2), the calculation of the minimum number of samples required is as follows.

$$n1 = n2 = 2\left(\frac{[1{,}64\ + 1{,}28]\ 5}{5}\right)^2 = 17{,}05\ \approx 17\ pharmacist/Groups$$

The sample size calculation for the trial phase was based on a numerical comparative formula for two independent groups. The minimum required sample size was 17 pharmacists per group, resulting in a total minimum sample size of 34 pharmacists. In the implementation of the study, a total of 46 pharmacists participated and were equally allocated into two groups: 23 pharmacists used the digital HYPOGLYRISK application, and 23 pharmacists used the conventional paper-based HYPOGLYRISK. The larger sample size improves statistical precision and reduces the potential risk of Type II error compared with the minimum required sample size.

6. Statistical Analysis

The primary outcome of digital HYPOGLYRISK was calculated by measuring the time required by two groups of pharmacists (digital vs conventional). The data produced was ratio numeric data so that parametric analysis could be carried out. If the data were normally distributed, then the data were analyzed using the independent t-test. Still, if the data were not normally distributed, then the data were analyzed using the Mann-Whitney U test.

Secondary outcomes were analyzed descriptively and analytically. The potential for human error was analyzed based on the number of pharmacist errors in both groups. The analysis used was a bivariate chi-square analysis followed by a size effect relative risk (RR) analysis. The outcomes of adaptability, interactiveness, rapid data access, simple data management, and practicality of data integration were described descriptively in the results and discussion section based on the pharmacist's experience.

The baseline characteristic analysis of the pharmacist's demographic data in this study was also analyzed comparatively using the chi-squared test. The characteristics analyzed consisted of gender, age, pharmacy practice locations, and duration of pharmacy practice experience. All statistical analyses were conducted using a significance level of 0.05, corresponding to a 95% confidence level. Statistical significance was determined at $p < 0.05$, and confidence intervals were calculated where appropriate.

7. Ethical Consideration

Since the study was a component of a bigger project, data collection was carried out appropriately. The Ethics Commission of Udayana University's Faculty of Medicine in Bali gave its approval under ethical clearance number 1165/UN.14.2.2.VII.14/LT/2024. The study was carried out in accordance with the Declaration of Helsinki, and confidentiality was upheld at all times, including informed consent.

8. Standard Reporting

The Standards for reporting quality of non-randomized evaluations of behavioral and public health interventions (TREND) principles for quasi-experimental research design served as the foundation for the presentation of the study's reports. The TREND reporting standard is basically adopted from the CONSORT guideline for reporting deprescribing trials without a randomization section. We reference the Improving the Quality and Transparency of Health Research (Equator Network) reporting guidelines on their official website.[23,24]

RESULT AND DISCUSSION

HYPOGLYRISK Apps Development

The Android-based digital HYPOGLYRISK application was successfully developed and tested for use in hypoglycemia risk assessment among ambulatory patients with type 2 diabetes mellitus. The HYPOGLYRISK program provided 21 fundamental menu capabilities for pharmacists to evaluate the risk of hypoglycemia in outpatients with type 2 diabetes mellitus (T2DM). The primary menu in this program was the severe hypoglycemia risk assessment menu for ambulatory T2DM patients, comprising 15 menus and functionalities. Simultaneously, the auxiliary menus included the measurement history recall menu (3 menus), the HYPOGLYRISK usage guide menu (1 menu), and the menu for accessing counseling foundations and educational materials offered to patients (2 menus).

The created digital HYPOGLYRISK was expected to possess a visual identity, so the logo represents the most feasible method to achieve this. The HYPOGLYRISK logo is intended to serve as a visual identity that conveys values and imagery to users. The HYPOGLYRISK logo and its application visualization are depicted in **Figure 1** and **Figure 2** below.

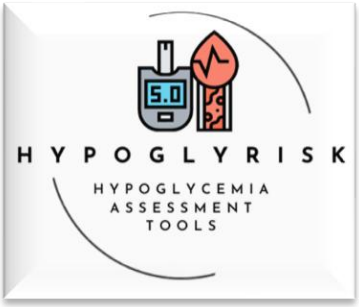

Figure 1. HYPOGLYRISK Android App Logo.

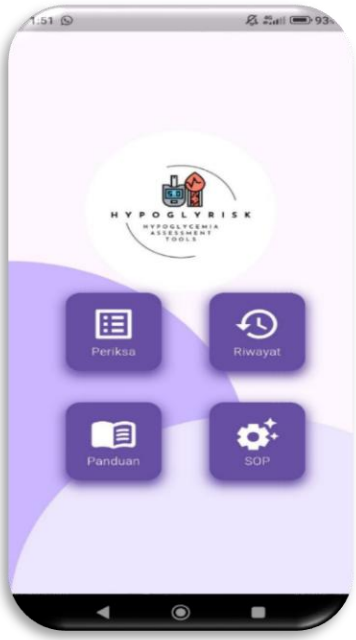

Figure 2. HYPOGLYRISK Android App Visualization.

Pharmacist Recruitment

Forty-six pharmacists participated in the HYPOGLYRISK Apss experiment, comprising 23 pharmacists in the digital HYPOGLYRISK user group and 23 pharmacists in the conventional HYPOGLYRISK user group (paper-based), with pharmacist characteristics detailed in **Table 1**.

Table 1. Comparison of Basic Characteristics of Pharmacists in the Digital and Conventional HYPOGLYRISK Groups.

No	Characteristics	Trial (n=23)	Control (n=23)	p-Value	Type of Analysis
1	**Gender**				
	Male (n %)	10 (43.48)	4 (17.39)	0.055	Chi-S
	Female (n %)	13 (56.52)	19 (82.61)		
2	**Ages (years)**				
	25-30 (n %)	14 (60.87)	21 (91.30)	0.132	Chi-S
	31-35 (n %)	4 (17.39)	2 (8.70)		
	36-40 (n %)	2 (8.70)	0 (0.00)		
	41-45(n %)	0 (0.00)	0 (0.00)		
	46-50 (n %)	2 (8.70)	0 (0.00)		
	51-55 (n %)	0 (0.00)	0 (0.00)		
	56-60 (n %)	1 (4.35)	0 (0.00)		
3	**Pharmacy Practice Locations**				
	General Hospital (n %)	14 (60.87)	13 (56.52)	0.263	Chi-S
	Primary Care (n %)	3 (13.04)	3 (13.04)		
	Community Pharmacy (n %)	5 (21.74)	2 (8.70)		
	Private Health Facility (n %)	1 (4.35)	5 (21.74)		
4	**Pharmacy Practice Experience**				
	< 5 years (n %)	6 (26.09)	15 (65.22)	0.008*	Chi-S
	> 5 years (n %)	17 (73.91)	8 (34.78)		

Information: n: numbers; Chi-S: Chi-Square.

The pharmacists participating in the trial test had a higher percentage of females (69.57%) compared to males (30.43%), with an average age of 30 ± 7 years. 58.70% of responders were hospital pharmacists, 15.22% were community pharmacists, and 13.04% were pharmacists at health centers and private health facilities. The demographic features of pharmacists, including gender, age, and the origin of their institutions, were consistent between the digital and conventional HYPOGLYRISK groups in this study ($p > 0.05$). One notably distinct trait was the duration of pharmacy practice. The traditional group comprised a greater number of pharmacists with less than five years of professional experience than the digital group. This scenario arose due to the predominance of young pharmacists, averaging under 35 years of age, practicing in outpatient treatment in Bali Province. This condition did not influence the outcomes of the

risk assessment, as the items of the HYPOGLYRISK instrument had successfully undergone the inter-rater reliability evaluation.[8,9]

Black Box Testing

The findings from the black box validation indicate that all modules inside the HYPOGLYRISK mobile Android application operate correctly, as illustrated in **Table 2**. The test indicated that there were no errors or impediments in accessing the system menus, computing the hypoglycemia risk score, and utilizing the HYPOGLYRISK user guide feature.

All users (n=46) submitted valid checkpoints across all categories of software tests, yielding anticipated results. No flaws, failures, freezes, lags, or crashes were detected during the operation of the HYPOGLYRISK digital application. This outcome occurred because the produced program was local, accessible offline, not connected to a server, and solely depended on the user's device as a local host, encompassing storage media (device storage and random access memory). Furthermore, all pharmacists utilized Android devices operating on the latest Android OS, specifically Android 14 "Upside Down Cake," during the application testing in September 2024, which ensured seamless functionality of the digital HYPOGLYRISK without any complications.

Table 2. Black Box Testing.

No	Test Components	Type of Test	Results (n=46)	Black Box Interpretation
1	Access Menu	Access the HYPOGLY RISK application.	No issue	Valid
		Access the “Check” menu.	No issue	
		Access the “History” menu.	No issue	
		Access the “Guide” menu.	No issue	
2	Risk Score Calculation	Fill in the patient's name.	No issue	Valid
		Fill in the gender.	No issue	
		Fill in the age.	No issue	
		Fill in the medical record number.	No issue	
		Filling in the Pharmacist's Name.	No issue	
		Incomplete data.	No issue	
		Filling in risk factor data items 1-8 (YES/NO button).	No issue	
		Trying the "Calculate Risk" button, Part A.	No issue	
		Trying the "Continue" button Part A.	No issue	
		Trying the "Back" button Part A.	No issue	
		Filling in Part B items 1-8 data.	No issue	
		Trying the “?” button on items 1-8, part B.	No issue	
		Try the “Calculate Risk” button in the Medication Safety section.	No issue	
		Try the “Finish” button in the Medication Safety section.	No issue	
3	Risk Assessment History	Calling up the examination history.	No issue	Valid
		Trying the “export data” button.	No issue	
		Trying the “delete” examination history button.	No issue	
4	Application User Guide	Accessing the detailed HYPOGLYRISK guide.	No issue	Valid
		Accessing the hypoglycemia education guide.	No issue	
		Trying to “download” the hypoglycemia education guide.	22 pharmacists' devices require manually setting storage permissions for apps.	

Time Efficiency Evaluation

The mean measurement duration for hypoglycemia risk in simulated outpatient diabetes patients was 6 minutes and 9 seconds in the digital group and 7 minutes and 15 seconds in the traditional group. This resulted in a time disparity of 1 minute and 6 seconds (**Table 3**).

Table 3. Comparison of Time Efficiency of Digital and Conventional HYPOGLYRISK.

Patients Simulation Case Categories	Digital HYPOGLYRISK (Android Mobile Apps) (n=23) Mean ± SD (Min/Sec)	Conventional HYPOGLYRISK (Paper Base) (n=23) Mean ± SD (Min/Sec)	Efficiency Difference	p-Value	Type of Analysis
Low Risk	5’56” ± 46”	6’46” ± 54”	0’50”	0.003*	MWU
Moderate Risk	6’33” ± 47”	8’12” ± 53”	1’39”	0.001*	MWU
High Risk	5”58” ± 46”	6”46” ± 56”	0’48”	0.003*	MWU
Measurement Time of All Categories (Mean ± SD)	6’9” ± 49”	7’15” ± 1’7”	1’6”	0.001*	MWU

Information: n: number; SD: standard deviation; ’: minutes; ”: second; *: statistically significant; MWU: Mann-Whitney U test.

Table 3 indicates that the duration for assessing the risk of severe hypoglycemia in diabetes mellitus patients within the digital HYPOGLYRISK group was greatly reduced. This condition asserts that the digital HYPOGLYRISK application was more efficient in measurement time than its conventional counterpart.

Potential Human Error Evaluation

Table 4 indicates that when patients presented many items at risk of hypoglycemia, the mistake rate in the score summing conducted by pharmacists in the standard HYPOGLYRISK group was elevated. The utilization of traditional paper-based HYPOGLYRISK results in a 3.3-fold increase in scoring errors compared to the digital version ($p < 0.05$).

Discrepancies were identified when pharmacists totaled the ratings for each established HYPOGLYRISK item. The inaccuracy in aggregating the scores will affect the determination of the patient's risk category, whether it is classified as low, moderate, or high risk. Discrepancies identified in traditional HYPOGLYRISK were entirely absent in digital HYPOGLYRISK. This situation reinforces the argument that the utilization of digital HYPOGLYRISK was more advantageous than its conventional counterpart. The utilization of digital HYPOGLYRISK not only enhances measurement efficiency but also mitigates the human error element in evaluating the risk of severe hypoglycemia. Digital HYPOGLYRISK assists pharmacists in concentrating on elements within HYPOGLYRISK that accurately reflect the patient's state, free from the encumbrance of technological or manual issues.

Table 4. Comparison of Total Score Calculation Errors Between Digital and Conventional HYPOGLYRISK.

Simulation Case Categories	Error in Digital HYPOGLYRISK (n=23) n%	Error in Conventional HYPOGLYRISK (n=23) n%	p-Value	RR CI95% (Moderate-High Risk)	Type of Analysis
Low Risk (n=46)	0 (0)	0 (0)			
Moderate Risk (n=46)	0 (0)	11 (47.83)	0.001*	3.30* (2.29-4.76)	Chi-S and RR
High Risk (n=46)	0 (0)	15 (65.22)			
Total (n=69)	0 (0)	26 (37.69)			

Information: n: numbers; RR: relative risk; Chi-S: Chi-Square; CI: confidence interval; *: statistically significant.

User Acceptance Test (UAT)

The User Acceptance Testing (UAT) performed on 46 participants yielded a user acceptance score of 89.84, categorizing it within grade A: very good (**Table 5**). This outcome suggests that the typical user encounters no challenges when utilizing HYPOGLYRISK digital. Users report the advantages of the HYPOGLYRISK digital application through favorable feedback, and no technical issues or functional deficiencies were identified in its measurement of severe hypoglycemia risk in patients with type 2 diabetes mellitus. A "very good" UAT score can be attained due to the application's design, which is simple and user-friendly, requiring minimal storage media and random access memory (RAM), resulting in a fast and lightweight performance. Additionally, the HYPOGLYRISK digital application does not require an internet connection to operate.

User testimonials concerning adaptability, interactivity, speedy data access, ease of data management, and the practicality of data integration were gathered in this test. All pharmacists who utilized the HYPOGLYRISK application concurred on all these facets.

Table 5. Digital HYPOGLYRISK User Acceptance Test.

No	Statement to users (n=46)	Statement Type	Mean User Acceptance Score (Score range: 0.00-4.00) $\bar{x} \pm SD$
1	I am thinking of using the HYPOGLYRISK application to assess the risk of hypoglycemia in patients with type 2 diabetes mellitus.	Positive	3.74 ± 0.44
2	I find the HYPOGLYRISK application complicated to use.	Negative	3.70 ± 0.47
3	I find the HYPOGLYRISK application easy to use.	Positive	3.61 ± 0.49
4	I need help from other people or technicians to use the HYPOGLYRISK application.	Negative	3.46 ± 0.50
5	I feel that the features in the HYPOGLYRISK application are working properly.	Positive	3.39 ± 0.49
6	I feel that many things are inconsistent (not harmonious) in the HYPOGLYRISK application.	Negative	3.48 ± 0.51
7	I feel that other people will understand how to use the HYPOGLYRISK application quickly.	Positive	3.74 ± 0.44
8	I feel that the HYPOGLYRISK application is confusing.	Negative	3.52 ± 0.51

No	Statement to users (n=46)	Statement Type	Mean User Acceptance Score (Score range: 0.00-4.00) x̄ ± SD
9	I feel that there are no obstacles to using the HYPOGLYRISK application.	Positive	3.61 ± 0.49
10	I need to get used to it first before using the HYPOGLYRISK application.	Negative	3.70 ± 0.47
Crude score (n=46)			**1653.0**
Adjusted score (n=46)			**4132.50**
Mean of adjusted score (Score range: 0-100) (n=46)			**89.84**
User acceptance of the HYPOGLYRISK application			**Grade A (Very Good)**

Information: n: number; x̄: mean; SD: standard deviation; number of adjusted scores: crude score x 0.25; average adjusted score: number of adjusted scores/(n=46).

Discussion

Converting HYPOGLYRISK into a digital format was considered an appropriate measure in this study. This application form improved pharmacists' efficiency in assessing hypoglycemia risk and reduced errors in the evaluation process. A review study demonstrates that the adoption of information technology systems substantially reduces medication errors and protects patients undergoing ambulatory therapy. This study determined that information technology systems were crucial in mitigating the prevalence of pharmaceutical errors, which result in patient harm and elevated expenditures; hence, their prevention emerged as a global priority for healthcare systems.[25–27] Information technology (IT) systems, such as computerized physician order entry, automated dispensing, barcode medication administration, electronic medication reconciliation, and personal health records, are considered critical components in strategies to reduce medication errors, supported by a growing body of evidence-promoting their widespread implementation. Nonetheless, considerable challenges, such as the high costs linked to these systems, require resolution through economic incentives and political regulation.[28–30] The findings of this study are consistent with the growing body of literature demonstrating that digital clinical tools can enhance medication safety and support clinical decision-making in routine healthcare practice.[31,32] Several digital health applications have been developed to assist healthcare professionals in risk assessment and clinical monitoring, particularly in chronic disease management. Mobile-based clinical decision support systems have been shown to improve workflow efficiency, reduce documentation errors, and facilitate rapid access to patient-related information during care delivery.[33,34] Compared with conventional paper-based assessment tools, digital platforms allow automated calculation, structured data recording, and improved accessibility, which may contribute to safer medication management practices.

The digital HYPOGLYRISK was effective in reducing mistakes when evaluating the hypoglycemia risk group. This situation facilitates the accuracy and precision of a series of pharmaceutical service tasks. The effectiveness of measuring hypoglycemia risk over time was considered a critical aspect of attracting attention. The deployment of digital HYPOGLYRISK in this study exhibited significantly enhanced time efficiency. Patients typically demonstrate a pronounced dislike for delays. Consequently, waiting time is often correlated with patient satisfaction. In Indonesian healthcare institutions, patient waiting time for prescription medication services is an indicator of the quality of pharmaceutical care.[35] The patient's risk profile will be assessed shortly before the medicine dispensing phase. Patients identified as low risk will be promptly summoned for dispensing, accompanied by a concise instructional session lasting 1-2 minutes. Patients identified as moderate to high risk will be invited to the counseling room for educational interventions and outpatient medication dispensation. The operation necessitates 10 to 15 minutes. This pharmaceutical service is considered ideal as it adheres to the standard waiting time for services. Pharmacists can provide pharmaceutical services centered on medication safety while maintaining patient wait times. Digital HYPOGLYRISK substantially facilitates this phase and process.[8,26,28] In the present study, the digital HYPOGLYRISK application significantly reduced the time required for hypoglycemia risk assessment compared with the conventional paper-based method. Although the absolute difference in assessment time appears modest, even small improvements in efficiency may be clinically relevant in busy ambulatory pharmacy settings where pharmacists manage multiple patients and medication-related tasks simultaneously. Furthermore, the observed reduction in scoring errors represents an important practical advantage. Manual calculation errors in paper-based tools may lead to incorrect risk classification, which could potentially influence the identification of patients requiring additional counseling or medication safety interventions. The elimination of such errors through automated scoring may therefore contribute to improved accuracy of clinical risk screening.[36,37]

From a clinical perspective, the integration of digital screening tools such as HYPOGLYRISK may strengthen pharmacist-led medication safety services for patients with type 2 diabetes mellitus. Early identification of patients at higher risk of hypoglycemia enables pharmacists to provide targeted counseling, medication review, and monitoring strategies. In resource-limited healthcare environments, simple mobile applications that operate offline and require minimal infrastructure may represent a practical approach to support safer diabetes care and improve patient outcomes.

Limitation

This research exhibited multiple shortcomings. The HYPOGLYRISK App is exclusively built for Android smartphones. This problem prevents pharmacists from using devices with non-Android operating systems from utilizing them. Another drawback is that the developed program does not employ a server. This circumstance obstructs the straightforward implementation of the data integration procedure for EHR. The application has numerous benefits, such as an intuitive user interface, ease of use, practicality, efficient performance, minimal errors, bug-free operation, and affordable operational costs.

CONCLUSION

The digital HYPOGLYRISK application was successfully developed and demonstrated practical advantages compared with the conventional paper-based instrument. Pharmacists using the digital application required significantly less time to complete hypoglycemia risk assessment than those using the printed version, indicating improved efficiency in screening activities. In addition, the digital application eliminated manual scoring errors and received very high user acceptance from pharmacists. These findings suggest that the digital HYPOGLYRISK application can enhance the efficiency and reliability of pharmacist-led hypoglycemia risk screening among ambulatory patients with type 2 diabetes mellitus.

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GENERATIVE AI DISCLOSURE STATEMENT

During the preparation of this manuscript, the author(s) used Grammarly Premium for language editing, grammar correction, and improvement of writing fluency. After its use, the author(s) thoroughly reviewed, verified, and revised all content to ensure accuracy, originality, and scientific integrity. The author(s) take full responsibility for the final content of the published article.

AUTHOR CONTRIBUTION STATEMENT

Made Krisna Adi Jaya: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Validation, Project administration, Writing—Original Draft, Writing—Review & Editing; **Zullies Ikawati**: Conceptualization, Methodology, Supervision, Validation, Writing—Review & Editing; **Fita Rahmawati**: Methodology, Investigation, Validation, Writing—Review & Editing; **Nanang Munif Yasin**: Methodology, Investigation, Data curation, Writing—Review & Editing; **I Gusti Ngurah Anom Cahyadi Putra**: Software, Application development, User interface design, Software validation, Technical support, Writing—Review & Editing.

CONFLICT OF INTEREST DECLARATION

The paper was written independently. All authors disclose no financial or personal relationships with other people or organizations that could inappropriately influence the study.

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