

## E-MunDiabetes

### A Mobile Application for Nursing Students on Diabetes Education During the COVID-19 Pandemic

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The COVID-19 pandemic caused tremendous disruption of health systems worldwide. Patients with diabetes are at a high risk of COVID-19 exposure because face-to-face consultations have been standard for diabetes management. This study describes the development and validation of a mobile application for nursing students on diabetes education during the COVID-19 pandemic. The application was developed by a certified diabetes educator nurse and by a freelance programmer and, in the next step, validated in terms of content and appearance by a group of expert nurses on diabetes ( $n = 29$ ), nursing students ( $n = 40$ ), and information technology experts ( $n = 11$ ). Validity indexes of 0.99 for content and 0.92 for appearance were obtained, and usability values of 78.9 ( $\pm 15.3$ ) and 78.2 ( $\pm 10.8$ ) were obtained from nursing and information technology experts, respectively. The self-assessment and satisfaction items evaluated by nursing students had a total agreement of 96.3% and an intraclass correlation coefficient of 0.91. Both the content and the appearance of the application were considered adequate, and the usability scores indicate that the application is useful and easy to use.

**KEY WORDS:** COVID-19, Diabetes mellitus, Health education, Mobile applications, Validation study

The global crisis brought about by COVID-19 required nurses and students to advance their knowledge about the disease and adapt to new teaching and learning methods, including technological innovations, focused on

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knowledge dissemination, shifting the focus to health needs that emerged amid the pandemic.<sup>1</sup> Among the areas of nursing practice that require continuous care, monitoring of people with diabetes stands out because diabetes is a risk factor for severe COVID-19. New pedagogical strategies for diabetes management such as educational technologies and mobile applications (apps) must be implemented and validated, especially in the context of pandemics, as they do not require face-to-face encounters.<sup>2,3</sup>

A randomized clinical trial has demonstrated that apps can facilitate contemporary teaching, calling on professionals to develop, validate, and use technology for teaching.<sup>4</sup> Nurses and researchers have invested in developing apps to support different dimensions of care for people in social isolation, especially in recent years.<sup>5</sup> Despite this, to the best of our knowledge, no app exists for diabetes education during the COVID-19 pandemic. This study describes the development and validation of a mobile app for nursing students on diabetes education during the COVID-19 pandemic.

## METHODS

A methodological study was conducted from April to June 2021, using Galvis-Panqueva and Mendoza's<sup>6</sup> framework for digital technology creation. The study was organized in four steps: (1) analysis: selection and elaboration of the didactic content; (2) design and development: instruction planning and virtual content development; (3) evaluation and administration: evaluation of the content, appearance, and usability of the object by experts; and (4) self-assessment and satisfaction evaluation by nursing students.

In step 1, the didactic content that would compose the app was defined. Two scoping reviews and a survey of apps in virtual stores of the main operating systems in Brazil (Google Play Store and Apple App Store) were conducted. The reviews identified strategies for diabetes self-management during the pandemic and digital technologies available for diabetes care created by nurses and other healthcare workers. After this step, themes and media were developed to compose the app's content.

Step 2 was performed in two substeps: content definition and development. The content definition involves the definition of the educational content; screen navigation structure; visual, functional, and typography organization; layout composition; and identification of perception issues, such as font type and size, spacing, colors, and positioning of illustrations, texts, links, and videos, and interactivity structure between systems. The content was organized so that users could understand it and navigate through the app efficiently and effectively. A professional designer was hired to create the images presented throughout the app sections, standardize illustrations, and provide consultancy. In addition, the information architecture and a basic navigation flow of the system were created.

Still, during the content definition substep, the main researcher created sketches to direct the development of the initial interface of the system. The sketches were created using the Marvel design platform (Marvel, London, UK), which has a free version available for use. Then, the app's visual design was created, meeting all requirements necessary to reach the best final format. Digital technologies must be easy to use, objective, organized, comfortable, pleasing to the eye, and efficient.<sup>6</sup> The app screens were organized in a coherent way and with accessible language.

The development substep, carried out by the same professional that collaborated in the first substep, involved coding and storing the contents of the app on the chosen platform. The app project was entitled "E-MunDiabetes," developed using Facebook's JavaScript React Native library in March 2015. The app can be used on various platforms (iOS and Android) or cross-platform. The Expo.io framework, a set of tools and services built around the React Native platform and deployed on iOS and Android, was used to expand possibilities and accelerate the development. The final app was developed for the Android platform because of the high cost for deployment on the iOS system.

In step 3, content and appearance validation and usability analysis were performed by two groups of experts consisting of nursing and information technology (IT) collaborators. The group of nursing experts was composed of nurses with practical experience in caring for people with diabetes. The IT experts had a minimum of 2 years of experience in IT, computing, programming, or Web site creation.

The process of choosing the experts was done through a search on the Lattes Platform, a government-produced list of scientists' curricula including all science subjects of Brazil. In addition, nominations by third parties were accepted (snowball technique). The experts were selected to participate based on their expertise, using the criteria described by Jasper.<sup>7</sup> At least two of the following had to be present: having skills or knowledge gained by experience, having specialized skills or knowledge, being regarded as an authority, being skilled in a particular type of study, being approved by

an expertise test, and having an expert rating assigned by a recognized authority. An intentional nonprobabilistic sampling method was used, and 29 nurses and 11 IT experts participated, following the recommendation of an odd number of experts to obtain consistent measurements.<sup>8</sup>

The experts were invited to participate via email. The instruments were made available via REDCap along with the consent form, a link to access E-MunDiabetes, a PDF file with install instructions, and screen images. The instrument sent to the nursing experts was composed of four parts, as follows: (1) academic and professional data, (2) content validation, (3) appearance validation, and (4) usability assessment. In turn, the instrument sent to IT experts was composed of the following items: (1) academic and professional data, (2) appearance validation, and (3) usability assessment.

The content validation instrument had 18 questions divided into the following domains: objective, structure/presentation (organization, structure, strategy, coherence, and sufficiency), and relevance (significance, impact, motivation, and interest). The items were scored using a Likert-type scale ranging from 1 to 2 (0 = disagree, 1 = partially agree, and 2 = strongly agree).<sup>9</sup> Another instrument with 12 questions was used for appearance validation, with Likert scales ranging from 1 to 5 (1 = strongly disagree, 2 = disagree, 3 = partially disagree, 4 = agree, and 5 = strongly agree).<sup>10</sup>

The System Usability Scale (SUS) created by John Brooke in 1986 and validated in Brazil by Tenório et al<sup>11</sup> was used in the present study. The SUS is used to assess products, services, hardware, software, Web sites, and apps. It is structured as a set of questions with a score on a 5-point Likert scale, and its questions alternate good and bad usability aspects. To obtain the final usability score, the results need to subtract 1 from the odd question answers and subtract the value of the even question answers from 5. The value obtained is then multiplied by 2.5, providing the final score (0–100). Values <68 indicate poor usability, and values of 85 or more indicate good usability.<sup>12</sup>

Step 4 consisted of evaluating the app by conducting a user-centered approach. This step was taken after the app was readjusted according to the judges' considerations. The participants were 57 nursing students from a university located in the Northeast of Brazil, and a convenience sampling method was used. Students at the eighth (n = 27) and ninth (n = 30) quarters of a nursing program held at a public university were included. The only criterion used for inclusion was availability to participate in the study in extra-class hours. Students younger than 18 years were excluded. The students were invited to access the app and its contents and to fill out questionnaires.

The recruitment took place through an electronic invitation with information about the research. Students who accepted to participate received an invitation letter with information about

the study, a link to download the app, and a REDCap link to access the questionnaires. The questionnaires included a characterization form and a self-assessment and satisfaction questionnaire. Initially, 42 students accepted to participate, 15 did not respond to the invitation, and two did not complete all the required steps. Thus, 40 nursing students composed the final sample of the study.

The main researcher created the self-assessment and satisfaction questionnaire, with 20 items divided into four domains: organization, writing style, appearance, and motivation. Items are measured using a Likert scale (0 = disagree, 1 = partially agree, 2 = agree). The final score is calculated by joining all domains. In addition, the following questions were addressed: How often did you use this App? How much time have you spent using this App? Would you like to give suggestions for improving the App? Did you have any difficulty using the App? If so, please describe.

In the end, a blank space was provided to register criticisms/suggestions from the experts. The suggestions arising from the validation step were analyzed and accepted when pertinent. The text was professionally reviewed in the Portuguese language. A period of 20 days was granted for the return of the instruments, extended for an equal period for further clarification. When the instrument was not returned within the pre-established period, the expert was excluded from the study.

Data were tabulated in Microsoft Excel (Microsoft, Redmond, WA, USA) and exported for statistical analysis using SPSS version 23.0 (IBM, Armonk, NY, USA). Data were displayed in absolute and relative frequencies. The Shapiro-Wilk test was used to analyze the normality of the data. The mean and SD of the parametric data and the median and quartiles of the nonparametric data were also calculated. A minimum coefficient of agreement (CA) of 0.80 was adopted and used as a criterion for the permanence of contents in the app.<sup>13</sup> The binomial test was also used, with a significance level of  $P > .05$ , to verify the CA equal to or greater than 80% and an intraclass correlation coefficient (ICC) as a reliability measure, considering low-reliability values,  $<0.40$ ; moderate,  $0.40$  to  $0.75$ ; and excellent,  $>0.75$ .<sup>14</sup> The study was approved by the Research ethics committee of the State University of Ceará, under opinion no. 4.671.477 and certificate of appreciation no. 43713021.8.0000.5534 (April 26, 2021).

## RESULTS

E-MunDiabetes is a mobile app, developed based on the current guidelines for diabetes management and scientific evidence from the literature, created to assist healthcare workers and students provide diabetes education during global emergencies, such as the COVID-19 pandemic.

After a clinical evaluation with the target audience (nursing students), the software will be available for free on the Google

Play Store and the Apple App Store. The app is compatible with smartphones and tablets that operate in iOS and Android platforms and can be found using the search feature of these platforms by typing “E-MunDiabetes.” To download the app, the user needs access to the Internet, but once saved to the mobile device (phone or tablet), the app is available for offline use.

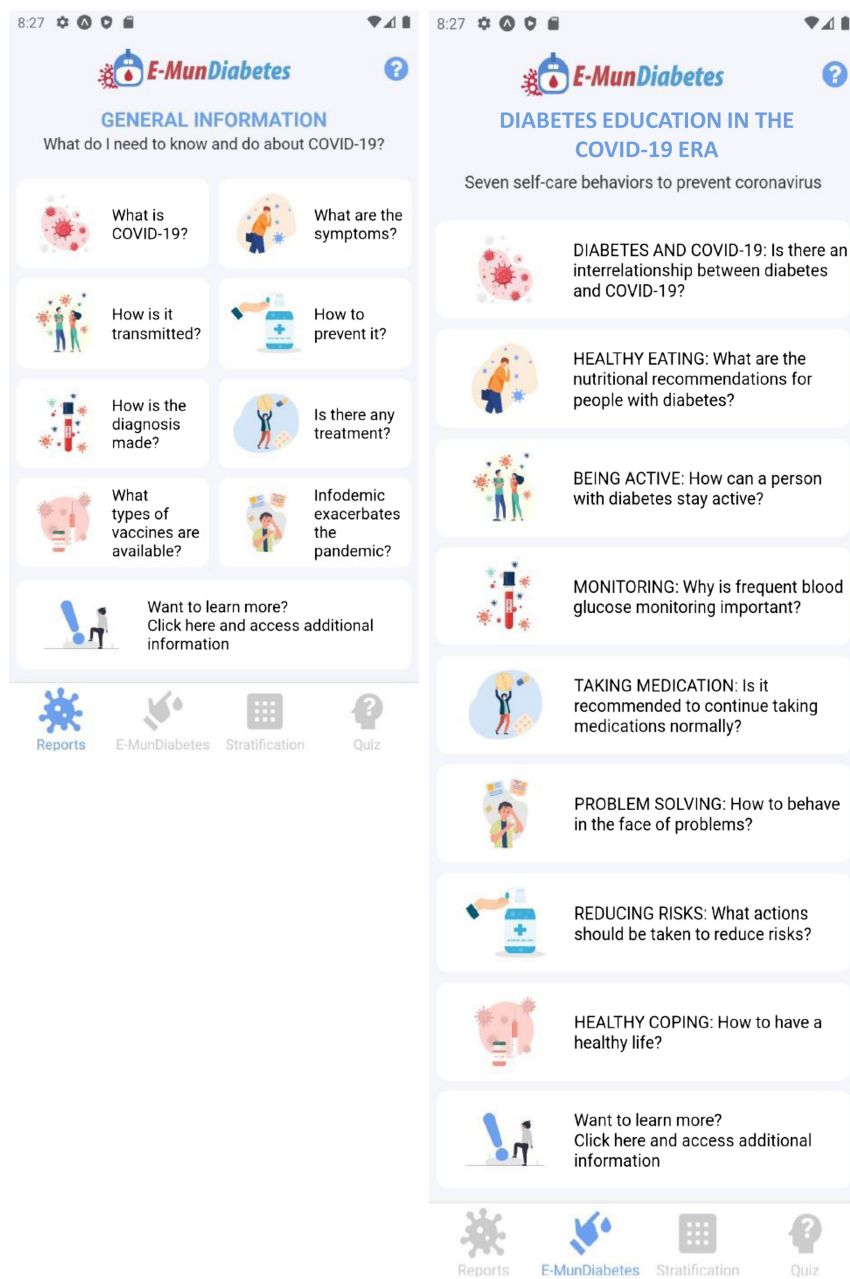
The app's home screen welcomes the user and provides information about the app's building, content, and navigation. The second screen labeled “General Information: What do I need to know and do about COVID-19?” displays nine bars that list information about the new coronavirus, as follows: (1) What is COVID-19? (2) What are the symptoms? (3) How is it transmitted? (4) How to prevent it? (5) How is the diagnosis made? (6) Is there any treatment? (7) What types of vaccines are available? (8) Infodemic exacerbates the pandemic, and (9) Want to learn more? Click here and access additional information. Bar 9 provides additional evidence-based content through links, contributing to user guidance on the app's topics.

The third screen, “Diabetes education in the COVID-19 era,” corresponds to the Association of Diabetes Care and Education Specialists' Seven Self-care Behaviors,<sup>15</sup> subdivided into the following sections: (1) Diabetes and COVID-19: Is there an interrelationship between diabetes and COVID-19? (2) Healthy Eating: What are the nutritional recommendations for people with diabetes? (3) Being Active: How can a person with diabetes stay active? (4) Monitoring: Why is frequent blood glucose monitoring important? (5) Taking Medication: Is it recommended to continue taking medications normally? (6) Problem Solving: How to behave in the face of problems? (7) Reducing Risks: What actions should be taken to reduce risks? (8) Healthy Coping: How to have a healthy life? and (9) Want to learn more? Click here and access additional information (Figure 1).

The functionality called “Stratification of a suspected case of COVID-19” is shown on the fourth screen. It indicates response options based on signs and symptoms of flu-like syndrome that represent the risk of having the new coronavirus, and then a result indicating the severity stratification and the clinical management actions that must be performed, following the Brazilian Ministry of Health's and the World Health Organization's guidelines,<sup>16,17</sup> as shown in Figure 2.

The flu-like syndrome is characterized by a sudden onset of fever accompanied by cough or sore throat or respiratory distress and at least one of the following symptoms: headache, myalgia, and arthralgia in the absence of another specific diagnosis. Patients with flu-like symptoms are considered potential COVID-19 cases and must be screened. COVID-19 testing is performed on these patients based on protocols. It is essential to stratify the severity of cases of flu-like syndrome to identify COVID-19 and severe acute respiratory syndrome quickly.<sup>17</sup>

## SPECIAL FOCUS: TECHNOLOGY USE DURING PANDEMIC



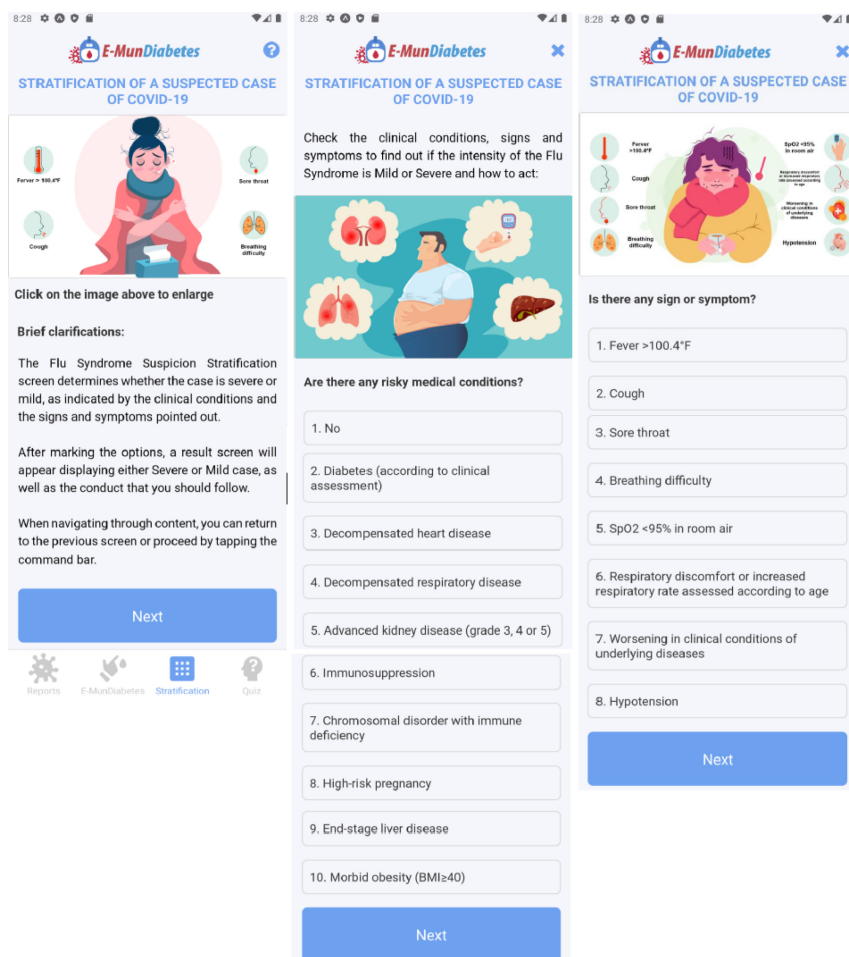
**FIGURE 1.** Screens 2 and 3 of the E-MunDiabetes app.

The fifth screen has a quiz feature. Initially, a brief clarification about the quiz's purpose is provided, and subsequently, questions with content addressed in the app are displayed. Each question has four alternatives (only one is correct). The first five questions refer to a clinical case, and the remaining are about diabetes education during the pandemic. The app also has a feedback screen that displays the number of correct answers and a global feedback screen.

The group of nursing experts consisted of 29 female nurses (24, 82%), with a mean age of 38.9 ( $\pm 11.3$ ) years, from different

regions of Brazil. The degree completion time ranged from 4 to 41 years, with a median of 11.3 (interquartile range, 5.5–24) years. In total, 15 participants (51.7%) had a doctorate, nine (31%) had a master's degree, and five (17.2%) had a specialization qualification. The median length of professional experience was eight (interquartile range, 4.0–13.5) years.

Eleven IT professionals participated in the study. Males predominated (9 [81.8%]), with a mean age of 34.4 ( $\pm 9.3$ ) years. The majority (7 [63.6%]) had a bachelor's degree in



**FIGURE 2.** Screen 4 of the E-MunDiabetes app.

IT (analysis and development of systems, computer science, and computer networks), with a median of 4 years (interquartile range, 3.0–14.0) of degree completion. Two participants (45.4%) had a doctoral degree, and three (27.3%) had a master's degree or were specialists/bachelors.

Forty nursing students participated, most of them female (33 [82.5%]), with a minimum age of 21 and a maximum age of 45 years (median, 23 years); most of them had no spouse (32 [80.0%]) or children (37 [92.5%]) and no paid activity (38 [95.0%]) and reported not having their income (32 [80.0%]). The predominant family income was of less than 2 Brazilian minimum wages (21 [52.5%]). As for academic data, most were in the ninth quarter of the nursing program (25 [62.5%]), were scholarship holders (24 [60%]), participated in a research group (32 [80%]), and had experience in caring for people with diabetes (25 [62.5%]).

Students stated that they had not taken classes focused on diabetes (33 [82.5%]) or COVID-19 (27 [67.5%]) before the survey. Most of them had experience in using digital

educational technologies (35 [87.5%]). Besides, most of them reported using smartphones to learn content from the undergraduate program (33 [82.5%]) and believed that mobile apps are useful for supporting learning (40 [100.0%]). Regarding the use of the app, most students have used it one to three times a day (31 [77.5%]) and for 1 to 2 hours a day (38 [95%]).

The content validation results indicated that the app is valid. All items evaluated achieved individual agreement rates greater than 90%, resulting in an overall agreement of 99%. A final ICC of 0.847 was obtained (content validation, Table 1). The content experts recommended spelling and grammar corrections, addition/reduction of information, and language standardization. All suggestions deemed pertinent were accepted.

Most items related to the app's appearance had an ICC >80%, with a total ICC of 92% (appearance validation). Only three items evaluated by the IT experts scored less than 80% (no. 5: The shapes of the illustrations are adequate for the type of material, no. 7: The arrangement of the figures

**Table 1. Content Validation Test Results**

Items	D	PA	TA	CA (%)	P	ICC	
Objective				100.0			
(1) Includes the proposed theme	0 (0%)	1 (3.2%)	30 (96.8%)	100.0	.226	0.778	
(2) Suitable for the teaching-learning process	0 (0%)	4 (12.9%)	27 (87.1%)	100.0	.226		
(3) Clarifies doubts about the topic of interest	0 (0%)	4 (12.9%)	27 (87.1%)	100.0	.226		
(4) Provides reflection on the theme	0 (0%)	4 (12.9%)	27 (87.1%)	100.0	.226		
Structure/presentation				98.8			
(5) Appropriate language for the target audience	0 (0%)	6 (19.4%)	25 (80.6%)	100.0	.226	0.804	
(6) Appropriate language as an educational material	0 (0%)	3 (9.7%)	28 (90.3%)	100.0	.226		
(7) Interactive language, allowing active involvement in the educational process	1 (3.2%)	10 (32.3%)	20 (64.5%)	97.0	.571		
(8) Correct information	0 (0%)	2 (6.5%)	29 (93.5%)	100.0	.226		
(9) Objective information	1 (3.2%)	6 (19.4%)	24 (77.4%)	97.0	.571		
(10) Clarifying information	0 (0%)	2 (6.5%)	29 (93.5%)	100.0	.226		
(11) Provides necessary information	0 (0%)	4 (12.9%)	27 (87.1%)	100.0	.226		
(12) Logical sequence of ideas	0 (0%)	3 (9.7%)	28 (90.3%)	100.0	.226		
(13) Current theme	0 (0%)	0 (0%)	31 (100%)	100.0	.226		
(14) Proper text size	2 (6.5%)	6 (19.4%)	23 (74.2%)	94.0	.429 <sup>a</sup>		
Relevance				100.0			
(15) Encourages learning	0 (0%)	3 (9.7%)	28 (90.3%)	100.0	.226		0.555
(16) Contributes to knowledge in the area	0 (0%)	1 (3.2%)	30 (96.8%)	100.0	.226		
(17) Awakens interest in the topic	0 (0%)	2 (6.5%)	29 (93.5%)	100.0	.226		
Total				0.99		0.847	

Abbreviations: CA, coefficient of agreement; D, disagree; ICC, intraclass correlation coefficient; P, binomial test; PA, partially agree; TA, totally agree.

<sup>a</sup>Alternative hypothesis states that the proportion of cases in the first group is <0.8.

is in harmony with the text, and no. 12: The illustrations help to change behavior and attitudes of the target audience). The total ICC was 0.831 (appearance validation, Table 2).

Suggestions given by the experts during the appearance validation consisted of image adjustment (color, size, and orientation), and all suggestions were accepted.

**Table 2. Appearance Validation Test Results**

Items	Nurses (n = 29)			Computers (n = 11)		
	CA (%)	P	ICC	CA (%)	P	ICC
1. The illustrations are suitable for the target audience.	97.0	0.571	0.964	90.0	0.431 <sup>a</sup>	0.831
2. The illustrations are clear and easy to understand.	93.0	0.429 <sup>a</sup>		90.0	0.431 <sup>a</sup>	
3. The illustrations are relevant to the target audience's understanding of the content.	93.0	0.429 <sup>a</sup>		82.0	0.000 <sup>a</sup>	
4. The colors of the illustrations are suitable for the type of material created.	97.0	0.571		100.0	0.569	
5. The shapes of the illustrations are suitable for the type of material created.	93.0	0.429 <sup>a</sup>		77.0	0.000 <sup>a</sup>	
6. The illustrations portray the daily life of the intervention's target audience.	97.0	0.571		100.0	0.569	
7. The arrangement of the figures is in harmony with the text.	86.0	0.175 <sup>a</sup>		77.0	0.015 <sup>a</sup>	
8. The figures used elucidate the content of the educational material.	93.0	0.429 <sup>a</sup>		82.0	0.000 <sup>a</sup>	
9. The illustrations help in exposing the theme and are placed in a logical sequence.	93.0	0.429 <sup>a</sup>		100.0	0.569	
10. The illustrations are in adequate quantity in the educational material.	86.0	0.175 <sup>a</sup>		82.0	0.102 <sup>a</sup>	
11. The illustrations are in appropriate sizes in the educational material.	90.0	0.175 <sup>a</sup>		82.0	0.102 <sup>a</sup>	
12. The illustrations may help to change behaviors and attitudes of the target audience.	90.0	0.175 <sup>a</sup>		77.0	0.000 <sup>a</sup>	
Total	0.92		0.964	0.92		0.831

Abbreviations: CA, coefficient of agreement; ICC, intraclass correlation coefficient; P, binomial test.

<sup>a</sup>Alternative hypothesis states that the proportion of cases in the first group is <0.8.

**Table 3. Usability Assessment Results**

Nursing Experts (n = 29)			Information Technology Experts (n = 11)		
Experts	Usability		Experts	Usability	
	Score	Classification		Score	Classification
Nurse 1	80	Adequate	IT-1	72.5	Adequate
Nurse 2	100	Adequate	IT-2	80	Adequate
Nurse 3	100	Adequate	IT-3	95	Adequate
Nurse 4	80	Adequate	IT-4	70	Adequate
Nurse 5	75	Adequate	IT-5	70	Adequate
Nurse 6	100	Adequate	IT-6	70	Adequate
Nurse 7	92.5	Adequate	IT-7	87.5	Adequate
Nurse 8	97.5	Adequate	IT-8	60	Inadequate
Nurse 9	75	Adequate	IT-9	80	Adequate
Nurse 10	52.5	Inadequate	IT-10	82.5	Adequate
Nurse 11	72.5	Adequate	IT-11	92.5	Adequate
Nurse 12	50	Inadequate			
Nurse 13	92.5	Adequate			
Nurse 14	82.5	Adequate			
Nurse 15	80	Adequate			
Nurse 16	75	Adequate			
Nurse 17	67.5	Inadequate			
Nurse 18	72.5	Adequate			
Nurse 19	50	Inadequate			
Nurse 20	97.5	Adequate			
Nurse 21	72.5	Adequate			
Nurse 22	60	Inadequate			
Nurse 23	72.5	Adequate			
Nurse 25	87.5	Adequate			
Nurse 25	87.5	Adequate			
Nurse 26	97.5	Adequate			
Nurse 27	90	Adequate			
Nurse 28	65	Inadequate			
Nurse 29	62.5	Inadequate			
Mean ± SD	78.9 ± 15.3		Mean ± SD	78.2 ± 10.8	

The SUS scores given by nursing and IT experts were 78.9 (±15.3) and 78.2 (±10.8), respectively. Both scores indicate good usability. Among nurses, 22 (75.9%) gave scores >68, and of these, 12 (54.5%) gave scores of 85 to 100 points, indicating excellent usability. Among the IT experts, one (9.1%) gave a score <68, and three (27.3%) gave scores of 85 to 95, indicating excellent usability (Table 3). Suggestions regarding the system's navigation, the display of the screens, and better textual organization were accepted.

The self-assessment and satisfaction evaluation items had a total CA of 96.3%, indicating a great agreement among students. The final ICC was 0.91 (Table 4). The suggestions given by the students were related to images and content updates, and all of them were accepted.

It is emphasized that adjustments were made based on participants' suggestions, and the app's final version was sent back to experts and students for further evaluations. However,

in this new round, there were no answers. Experts and students evaluated the app positively and considered that it has clear information, meets the target audience's needs, favors the learning process, and is suitable for use.

### DISCUSSION

The present study resulted in the construction of E-MunDiabetes, an app that nurses and students can use to find and provide information about the new coronavirus, measure self-care behaviors, stratify flu-like symptoms, and advise potential COVID-19 patients quickly and easily. The novelty of this app is that it can be used for learning support, diabetes education, and COVID-19 stratification simultaneously.

The app also contains a quiz with 10 questions to measure students' comprehension of the content provided. Diabetes management inevitably changes during global emergencies such as the COVID-19 pandemic. Diabetes patients may

**Table 4.** Self-assessment and Satisfaction Evaluation of E-MunDiabetes by Users

Items	Disagree, n (%)	Partially Agree, n (%)	Agree, n (%)	CA (%)	P	ICC
<b>Organization</b>				95.8		
1.1 Did the opening of the app catch your attention?	3 (7.5)	10 (25.0)	27 (67.5)	92.5	.323 <sup>a</sup>	0.73
1.2 Is the content sequence adequate?	1 (2.5)	1 (2.5)	38 (95.0)	97.5	.399	
1.3 Is the app structure well organized?	1 (2.5)	5 (12.5)	34 (85.0)	97.5	.399	
<b>Writing style</b>				95.8		
2.1 Are the sentences easy to understand?	2 (5.0)	12 (30.0)	26 (65.0)	95.0	.601 <sup>a</sup>	0.74
2.2 Is the written content clear?	1 (2.5)	8 (20.0)	31 (77.5)	97.5	.399	
2.3 Is the text interesting?	2 (5.0)	9 (22.5)	29 (72.5)	95.0	.601 <sup>a</sup>	
<b>Appearance</b>				97.5		
3.1 Are the illustrations clear?	1 (2.5)	1 (2.5)	38 (95.0)	97.5	0.399	0.85
3.2 Do the illustrations complement the text?	1 (2.5)	2 (5.0)	37 (92.5)	97.5	.399	
3.3 Are the screens or sections organized?	1 (2.5)	8 (20.0)	31 (77.5)	97.5	.399	
<b>Motivation</b>				96.1		
4.1 Will anyone reading the content of this app understand what it is about?	5 (12.5)	15 (37.5)	20 (50.0)	87.5	.000 <sup>a</sup>	0.79
4.2 Were you motivated to read the app content to the end?	2 (5.0)	14 (35.0)	24 (60.0)	95.0	.601 <sup>a</sup>	
4.3 Does the educational material address issues relevant for supporting people with diabetes during the COVID-19 pandemic?	-	6 (15.0)	34 (85.0)	100.0	.129	
4.4 Did the app make you feel more confident in providing care to people with diabetes during the pandemic?	1 (2.5)	15 (37.5)	24 (60.0)	97.5	.399	
4.5 Was the quiz suitable for the app?	-	8 (20.0)	32 (80.0)	100.0	.129	
4.6 Are the 10 questions of the quiz easy?	-	24 (60.0)	16 (40.0)	100.0	.129	
4.7 Are the additional readings indicated in the app adequate?	2 (5.0)	5 (12.5)	33 (82.5)	95.0	.601 <sup>a</sup>	
4.8 Has your knowledge increased when using the app?	1 (2.5)	7 (17.5)	32 (80.0)	97.5	.399	
4.9 Could you have used the app better?	3 (7.5)	21 (52.5)	16 (40.0)	92.5	.000 <sup>a</sup>	
4.10 Did the app meet your expectations?	3 (7.5)	6 (15.0)	31 (77.5)	92.5	.323 <sup>a</sup>	
4.11 Is the app's theme relevant?	—	—	40 (100.0)	100.0	.129	
<b>Total</b>				96.3	—	0.91

Abbreviations: CA, coefficient of Agreement; ICC, intraclass correlation coefficient; P, binomial test.

<sup>a</sup>Alternative hypothesis states that the proportion of cases in the first group is <0.8.

find it difficult to control and monitor glycemic levels during blockade or quarantine. Thus, diabetes educators, physicians, nurses, and other health professionals need reliable and accurate information to facilitate patient care and self-management.<sup>18</sup>

A systematic review with meta-analysis of diabetes self-care interventions demonstrated that mobile apps facilitate remote management of health problems and data, providing personalized self-care recommendations, communication between the patient and medical team, and favoring shared decisions.<sup>19</sup> There are a variety of apps aimed at the population with diabetes. However, those that seek to promote self-care are restricted to basic functions, such as recording self-monitoring data and data delivery.<sup>20</sup>

E-MunDiabetes is a technological innovation in health, as it is an app based on the need to compile information based on updated scientific recommendations. Furthermore, the app combines basic and advanced operational functions to

provide an innovative and valid product. The validation of the app by the experts was satisfactory, as there was a pre-dominance of positive evaluations regarding the interface of the product.

The validation of E-MunDiabetes was conducted with the collaboration of experts from different regions of Brazil. This characteristic, evidenced in other studies,<sup>21,22</sup> is positive because it makes it possible to gather different specialized views on the topic addressed, especially in the culturally diversified Brazilian context. Consequently, different experiences, practices, and perspectives about diabetes cannot be neglected.

Appearance validation by nursing and informatics experts was also positive, indicating high reliability. The suggestions gathered during the validation process focused on standardizing the images and portraying the content, making the reading more fluid and harmonic. Images are important in any educational material, and they must be positioned in line with the text.<sup>23</sup> Because they are persuasive, they facilitate



the understanding and memorization of information and make educational materials less tiring to read.<sup>24</sup>

The usability of E-MunDiabetes proved to be good based on the experts' assessment. This fact allowed us to deduce that the app is pleasant and can be added to everyday life. The app must meet the user's basic needs and comply with clinical practices in the diabetes community. Based on this premise, usability tests become increasingly essential before making the app available to the end-user, as well-designed apps can improve user experiences.<sup>23</sup>

Building and validating technologies are fundamental and complex actions that require pedagogical attitudes and an adequate method. Without validation, there is a risk of elaborating inappropriate material and products without educational purpose.<sup>25</sup> The comments provided by experts and students were satisfactory and confirmed the adequacy of E-MunDiabetes.

The production of updated technologies on topics of global importance such as the COVID-19 pandemic contributes to health students' engagement in the fight against this disease and to the dissemination of new knowledge on health promotion actions.<sup>26</sup> The new mobile app proposed in this article will help students and nurses quickly find information about the new coronavirus while providing diabetes care.

Furthermore, early identification of patients at risk of having coronavirus allows for the rapid initiation of optimized supportive care and referral to specialized centers.<sup>17</sup> In this perspective, the functionality of flu-like syndrome stratification of the app can help professionals and students increase awareness and educate patients, as diabetes is a risk factor for severe COVID-19.<sup>18</sup>

In a study carried out in the Philippines on the evaluation of an educational app, nursing students attested to its quality through parameters such as ease of use, content organization, and structuring. Students considered the app an acceptable, reliable, and effective product that educators and students can use to improve the quality of nursing education.<sup>27</sup> Similarly, in the present study, agreement values obtained in the self-assessment and satisfaction evaluation indicate the validity and quality of the app. Among the items evaluated, the way structures and screens are organized was considered adequate. The content was considered clear, interesting, and relevant. Moreover, students agreed that using the app has improved their confidence and knowledge of the subject.

In health education, the use of mobile apps is relevant in the teaching-learning process, as it provides opportunities for the exchange of experiences and information between individuals in different contexts, expanding access to content, enabling engagement, limiting geographic barriers, and adapting teaching to particular needs.<sup>28</sup> E-MunDiabetes was created considering the need to compile information based on scientific recommendations. Furthermore, the app has basic and

advanced operational functions that provide a contemporary, valid, and satisfactory product.

In line with good practices in scientific publications and with health organizations' recommendations, technology in the pandemic has become one of the essential pillars for health services and, in particular, for monitoring and controlling diabetes. The educational technologies used during the COVID-19 pandemic can last for years, helping patients and providers face further challenges that may arise.

Study limitations include the delay in obtaining acceptance from some participants and difficulties downloading the app. Such limitations led to the withdrawal of some participants.

The main implication of the study for the advancement of scientific knowledge is the creation of an app that is valid in its content and appearance, with the potential to optimize diabetes education during pandemics and fill existing knowledge gaps. E-MunDiabetes is therefore an updated scientific, educational, and professional app that helps students and nurses, anywhere and 24 hours a day, apprehend scientific knowledge and clinical reasoning of utmost importance in the current pandemic and future outbreaks.

## CONCLUSION

The content and appearance of E-MunDiabetes were considered adequate, and it is expected that the app will be considered useful and easy to use by the target audience. The app's structure is anchored in updated diabetes management guidelines that consider the pandemic scenario, allowing people with diabetes to receive diabetes education during major global crises.

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