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LONG PAPER

Usability and acceptance of a digital screening tool for diabetes in four European countries: the DigiCare4You study

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Abstract

Digital screening programs and tools provide the potential for early detection of chronic diseases such as diabetes in the general population. The main purpose of the current paper is to present the findings of a multi-country study conducted with implementers (i.e., health professionals) and citizens (i.e., patients) to assess the usability and acceptance of a digital screening tool for type 2 diabetes screening. To this aim, 109 healthcare professionals and 71 citizens from four (4) European countries—Bulgaria, Albania, Spain, and Greece –participated in the study. The participants were requested to test the DigiCare4You tool, by completing instructed activities for user interaction, and were provided with questionnaires consisted of multiple sections that captured participants' characteristics, perceptions, attitudes, and testing experience. The perceived usability assessed through the System Usability Scale (SUS) was found to be satisfactory for both health professionals (SUS score = 73.9) and citizens (SUS score = 68.06), and the majority of the participants considered the tool as useful and easy to learn. The results show the digital tool's favorable usability among healthcare professionals and citizens in different regions, paving the way for its successful implementation and wider adoption in diabetes care.

Keywords Digital tools · Diabetes · Acceptance · Usability · Clinical practice

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1 Introduction

Diabetes is a prevalent and significant health issue worldwide, affecting millions of individuals and posing substantial challenges to healthcare systems [1, 2]. According to the World Health Organization (WHO), diabetes has reached epidemic proportions, with approximately 422 million people living with the condition globally [3]. This chronic disease not only results in severe health consequences for those affected but also places a considerable economic burden on societies and healthcare resources [4]. As the prevalence of diabetes continues to rise, it becomes increasingly crucial to focus on preventive measures to curb its impact [5].

Currently, the diagnosis of type 2 diabetes primarily relies on the clinical judgement of healthcare professionals, who assess patient-reported symptoms and conduct examinations, including measurement of blood glucose levels and glycated hemoglobin (HbA1C) [6]. While this approach has been the standard method for diagnosing diabetes, it may not always capture the early stages of the disease or identify individuals at risk before severe symptoms manifest [7, 8]. Early identification may delay or prevent disease progression allowing also the introduction of preventive strategies in time [9]. Therefore, there is a pressing need to explore alternative and more effective ways of screening and identifying diabetes earlier.

In this context, digital tools have shown potential for the prevention of diabetes [10–16]. Digital screening programs offer a convenient, scalable and accessible (24/7) approach to reaching a broader population through the use of digital tools such as web platforms or smartphone apps, making identification of people at risk for diabetes and its complications possible [14–18]. However, digital screening programs for diabetes in the general population are still in their infancy presenting research gaps, opportunities and challenges [17–20].

The potential of digital screening programs to detect early signs of diabetes or even prevent the onset of the disease altogether brings a new opportunity for healthcare organizations and citizens to fight diabetes at population level. By embracing digital solutions, healthcare professionals can augment their current diagnostic practices and expand their reach to high-risk populations [21]. Additionally, patients can benefit from a more proactive approach to their health, with the possibility of early intervention leading to better health outcomes and improved overall well-being [22].

Digital tools in healthcare can often become difficult to use, thereby hindering user engagement, as well as their integration into daily clinical practice [23, 24]. Therefore, examining and understanding the acceptance and usability of digital health tools is crucial, in terms of exploring whether user expectations are met, optimizing their design and functionality, and ensuring their smooth deployment [25, 26]. Despite the massive growth in the development of digital health apps, only a small proportion of studies have reported usability evaluations [27].

The aim of this paper is to present a study conducted to assess the usability and acceptance of a digital screening tool for diabetes type 2, among health professionals and citizens in four European countries: Bulgaria, Albania, Spain, and Greece. This tool was developed in the context of the DigiCare4You study that aims to deliver an intersectoral innovation involving digital tools for early screening, prevention and management of type 2 diabetes and hypertension. To the authors' knowledge this is the first digital screening tool for diabetes which is evaluated for acceptance across different population groups in Europe.

2 Methods and procedures

2.1 2.1 Digital Screening Tool

The DigiCare4You digital screening tool offers a scalable user-friendly interface for efficient diabetes screening in the community (Fig. 1). The process comprises two stages: 1st stage questionnaires for diabetes risk identification and 2nd stage questionnaires with blood results exams uploading. Implementers (i.e., healthcare professionals) create patient accounts and invite citizens (i.e., patients) to join the platform. Upon logging in, implementers can access their dashboard, displaying a comprehensive list of patients and their relevant information, including results from the Finnish Diabetes Risk Score (FINDRISC),[1] which is a validated risk calculator for type 2 diabetes. Patients have also access to their dashboard to view, edit and complete screening information regarding demographics, lifestyle, medical data and anthropometrics. Upon identification of risk for type 2 diabetes based on FINDRISC at the 1st stage questionnaires, citizens receive a digital leaflet with practical tips on how to change their health behaviours, in terms of improving diet and physical activity habits to reduce their risk for diabetes. Citizens identified to be at risk for diabetes (FINDRISC >= 10), are invited to the 2nd stage screening step which involves blood exams upload. Online manuals, videos, and instructions for the proper use of the tool are available for both implementers and citizens. Implementers and citizens use specific credentials for authorized access to

[1] FINDRISC: https://www.mdcalc.com/calc/4000/findrisc-finnish-diabetes-risk-score

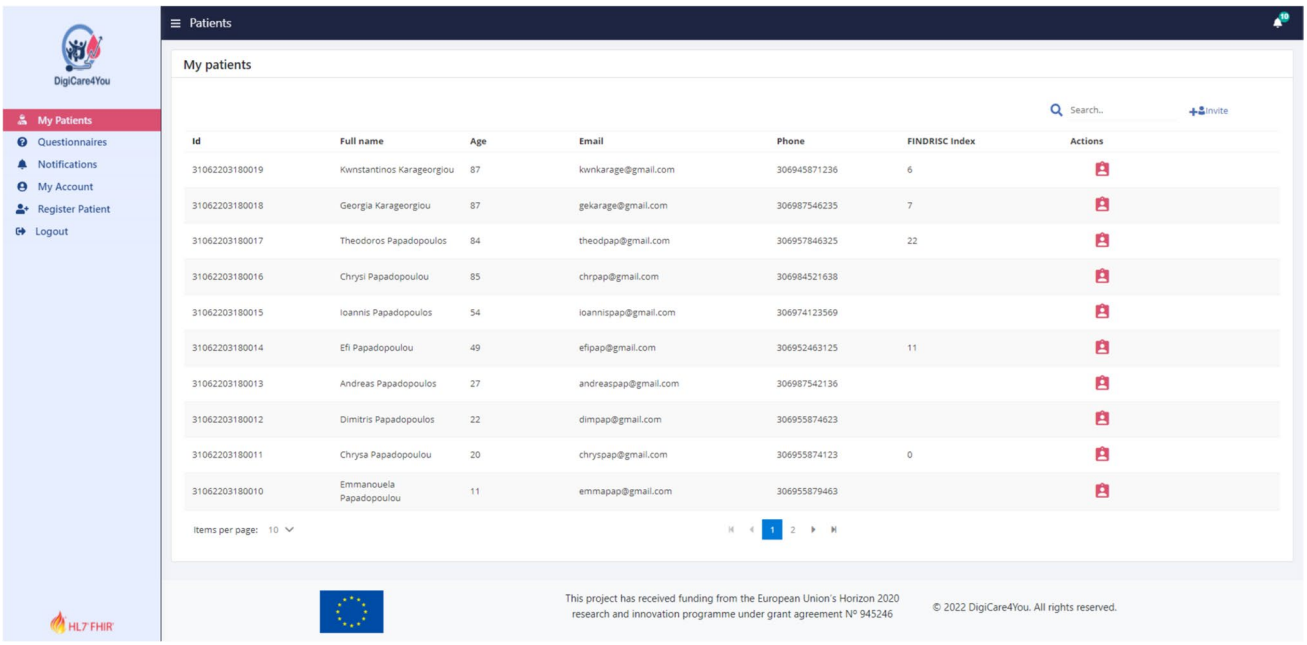

Fig. 1 Patient list displayed on implementer's home page in the digicare4you diabetes screening app

the digital tool. The functionalities of the tool are demonstrated in detail in published YouTube videos.[2],[3]

2.2 2.2 Study design

An online survey was designed to evaluate the acceptance and usability of DigiCare4You digital screening tool. The survey questionnaire was developed based on established frameworks and previous research on the technology acceptance model and usability assessment in healthcare settings [28]. It consisted of multiple sections that captured participants' perceptions, attitudes, and experiences related to the screening tool offered by DigiCare4You. The survey also included the testing of the digital tool to identify potential usability issues before their deployment.

The survey aimed to gather perspectives from two main groups: healthcare professionals (implementers) and citizens (patients). Participants were selected from four different European regions: Bulgaria, Albania, Spain, and Greece.

These regions were chosen to capture diverse healthcare contexts and cultural backgrounds, enabling a comprehensive understanding of the acceptance and usability of the DigiCare4You digital tool across different settings. For the healthcare professionals' group, a targeted recruitment strategy was employed to engage doctors and health professionals who had direct experience in clinical practice and were potential users of the digital tool. For the patients' group, targeted recruitment, through healthcare facilities and patient organizations was used to reach individuals who had utilized healthcare services and had potential experience with using digital health tools. Efforts were made to ensure representation from different age groups, genders, and socio-economic backgrounds within the patient sample.

2.3 *Survey content*

The survey questionnaire was designed to comprehensively explore the acceptance and usability of DigiCare4You digital tool among healthcare professionals and citizens. The demographic information section is dedicated on data concerning on participants' age, gender, region of residence, occupation (for healthcare professionals) and health status (for citizens), as well as familiarity with technology and digital health apps. The acceptance of the screening tool was assessed through questions on perceived usefulness, ease of learning, intention to use, and receiving information. Usability of the screening tool was evaluated based on system usability, ease of use, ability in learning the system and infrastructure availability.

2.3.1 Data collection

Participants after giving their consent for the conduct of the survey, tested the DigiCare4You tool, completing given activities for user interaction (e.g., login, enter patient

[2] DigiCare4You screening tool for implementers: https://www.youtube.com/watch?v=SPaCuEsbYkg

[3] DigiCare4You screening tool for citizens: https://www.youtube.com/watch?v=7KnIV8zkbSs

Table 1 Citizens characteristics

Characteristics	Greece (n = 35)	Bulgaria (n = 8)	Spain (n = 17)	Albania (n = 11)
Mean age (Range)	45.63 (23–83)	42 (23–60)	36.29 (22–66)	47.55 (27–60)
Gender (female)	74.3%	75%	52.9%	72.7%
employment status	Employed (71.4%) Retired (20%) Other (8.6%)	Employed (75%) Unemployed (25%)	Employed (76.5%) Unemployed (17.6%) Other (5.9%)	Employed (90.9%) Unemployed (9.1%)
Education level	University (48.8%) Masters (46.3%) Other (4.8)	Masters (40%) Doctorate (37.5%) Other (22.5%)	Masters (50%) Doctorate (50%)	Masters (58.3%) Other (41.7%)

Table 2 Healthcare professionals characteristics

Characteristics	Greece (n = 41)	Bulgaria (n = 40)	Spain (n = 16)	Albania (n = 12)
Mean age (range)	33.15 (23–62)	36.4 (23–56)	34.31 (24–63)	53 (26–81)
Gender (female)	17.1%	67.5%	87.5%	75%
Job position	Dietician/Nutritionist (36.6%) Nurse (19.5%), Physician/General Practitioner (9.8%) Other (34.1%)	Physician/General Practitioner (75%) Office worker (7.5%) Social worker (7.5%) Other (10%)	Dietician/Nutritionist (62.5%) Other (37.5%)	Physician/General Practitioner (33%) Nurse (16.7%) Research Scientist or Academic Professor (16.7%) Other (33.6%)
Education level	University (48.8%) Masters (46.3%) Other (4.9%)	Masters (40%) Doctorate (37.5%) Other (22.5%)	Masters (50%) Doctorate (50%)	Masters (58.3%) Other (41.7%)

details, complete questionnaires for 1st stage screening, upload examinations for 2nd stage screening and logout) to delve into the system's functionality. Based on their experience they were requested to engage in a survey. The survey was administered online using a secure survey platform, ensuring ease of participation and data collection.

2.3.2 Data analysis

Once the data was collected, the percentage rate was computed to summarize the participants' responses and identify patterns within the data. This analysis provided valuable insights into the overall acceptance, usability, and perceptions of the DigiCare4You digital tool among the participants in the four European regions.

In addition, the qualitative data obtained from Likert Scale questions, focused on the strength of agreement or disagreement on participants perceptions, e.g., regarding the use of digital presymptomatic health tools, or their intention on using the DigiCare4You digital solution.

Furthermore, the System Usability Scale (SUS) [29, 30] scores were calculated based on the participants' responses to the SUS questions. The System Usability Scale (SUS) is an effective and widely-used tool for assessing the usability of digital tools. It consists of a 10-item questionnaire with five response options for respondents from strongly agree to strongly disagree. The SUS scores provided a standardized quantitative measure of the overall usability of the DigiCare4You digital tool. Interpreting the SUS scores according to established benchmarks allowed for a comparative assessment of the tool's usability across different dimensions such as usefulness, user-friendliness, and user satisfaction.

Both quantitative indicators and descriptions were used thoroughly to assess how well people accept and use the DigiCare4You digital tool. The findings derived from the analysis contributed to a deeper understanding of the participants' perspectives and experiences, guiding the further development and refinement of the digital tool to better meet the needs of healthcare professionals and citizens.

3 Results

3.1 3.1 Screening tool testing

3.1.1 Participants

We present the testing results from a convenient sample of 180 participants (citizens and implementers) who tested the screening tool and responded to the online survey. The

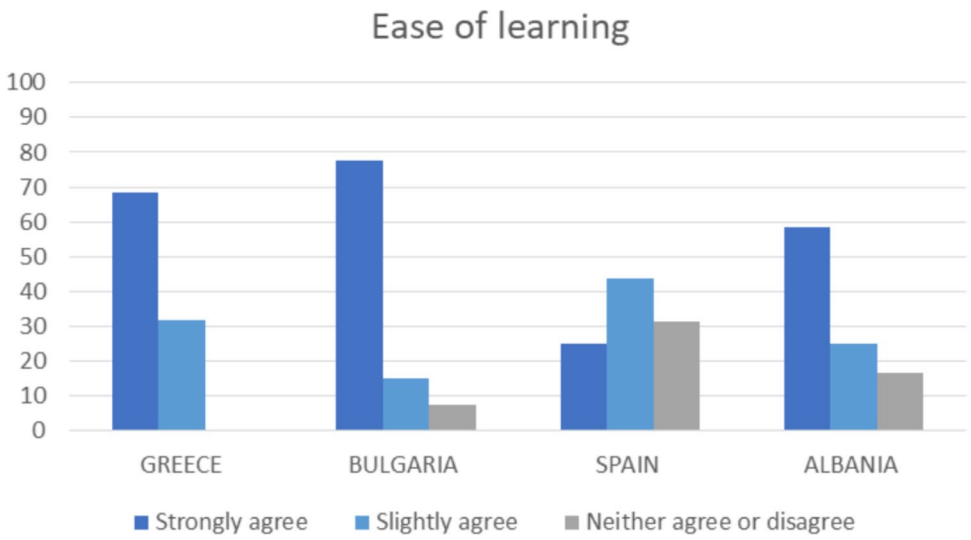

Fig. 2 Ease of learning of DigiCare4You system

demographic characteristics of the healthcare professionals (n = 109) as well as the citizens (n = 71) are depicted in Tables 1 and 2 respectively.

3.2 3.2 Testing results for implementers

The survey revealed that a significant majority of healthcare professionals in all regions reported frequent internet usage. In Greece, Bulgaria, and Spain, all participants (100%) reported using the internet every day. In Albania, 66.7% reported using the internet every day, with an additional 16.7% using it more than once a week. However, the use of presymptomatic health screening tools and Electronic Health Record (EHR) systems was not widespread among the participating healthcare professionals. In Greece, 61% of healthcare professionals reported never using presymptomatic health screening tools, while 61% reported never using an EHR system. In Bulgaria, 60% reported never using presymptomatic health screening tools, and 72.5% reported never using an EHR system. In Spain, 43.8% reported never using presymptomatic health screening tools, and 43.8% reported never using an EHR system. In Albania, 41.7% reported never using presymptomatic health screening tools, and 50% reported never using an EHR system. Despite limited familiarity with these tools, most professionals expressed belief in the potential of presymptomatic screening tools to guide patient management. In Greece, 85.1% agreed (strongly agree + slightly agree) with the usefulness of presymptomatic screening tools, while the percentages were 90% in Bulgaria, 75% in Spain, and 91.7% in Albania. Furthermore, healthcare professionals indicated a positive attitude towards the ease of learning and adopting such tools.

In Greece, 99.2% believed they could easily learn to use the system, while the percentages were 92.5% in Bulgaria, 75% in Spain, and 83.3% in Albania (strongly agree + slightly agree) (Fig. 2).

Concerning the regular use of a system like this one and the potential to bring major changes in regular clinical practice, healthcare professionals across regions advocated that the use of such a system will imply major changes in their clinical practice. In Greece, 87.8% agreed that the use of such a system would lead to major changes, while the percentages were 87.5% in Bulgaria, 81.3% in Spain, and 83.3% in Albania (Fig. 3). These findings indicate that healthcare professionals recognize the transformative potential of the DigiCare4You system.

Healthcare professionals from various regions expressed their intent to use the system, though sentiments vary. Spanish healthcare professionals lean towards skepticism, while Albanian healthcare professionals are notably enthusiastic. In Greece, 90.2% agree. Bulgaria shows 90% agreement. Spain reflects 43.8% agreement and 31.3% neutrality. Conversely, in Albania, a striking 100% agree (Fig. 4).

Across the 4 regions, SUS scores ranged between 22,5 and 100 ($\mu = 73.9$, $\sigma = 19.83$) indicating overall good usability. In Greece, SUS scores ranged between 47.5 and 100 ($\mu = 76.71$, $\sigma = 14.34$). In Bulgaria, SUS scores ranged between 22.5 and 100 ($\mu = 81.88$, $\sigma = 22.16$). In Spain, SUS scores ranged between 40 and 85 ($\mu = 60.78$, $\sigma = 13.93$). In Albania, SUS scores ranged between 30 and 82.5 ($\mu = 55.42$, $\sigma = 14.92$).

3.3 3.3 Testing results for citizens

The survey showed minor differences in employment and education levels between regions. In Greece, most participants were employed (71.4%), while in Bulgaria, Spain, and Albania, employment was also the dominant status (75%, 76.5%, and 90.9%, respectively). In the current study,

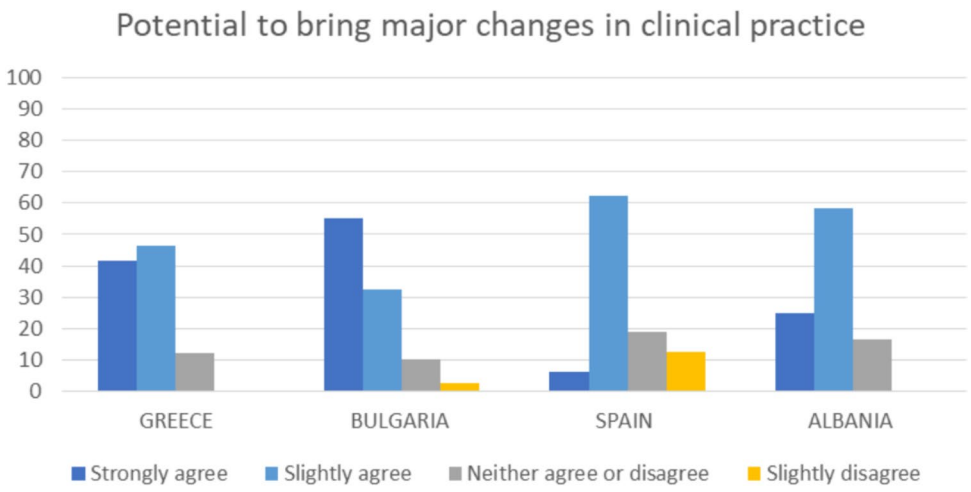

Fig. 3 DigiCare4You system potential to bring major changes in regular clinical practice

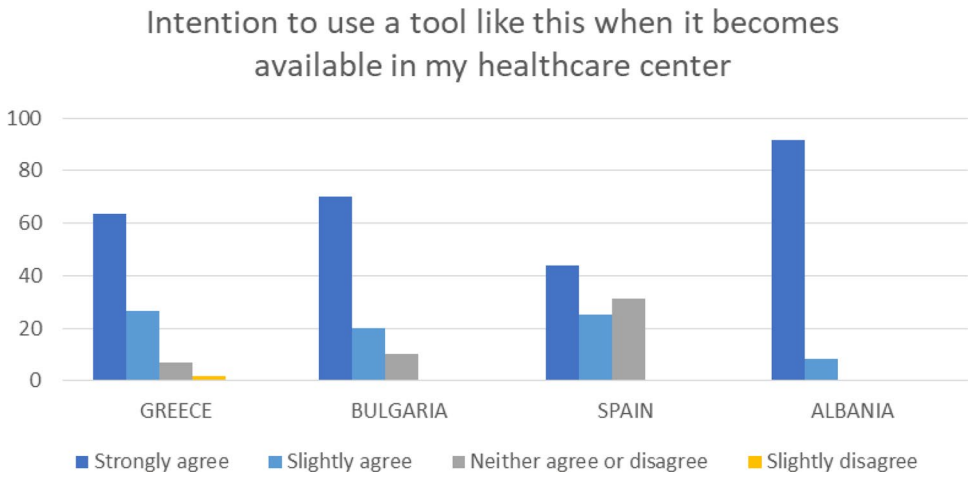

Fig. 4 Intention to use similar with DigiCare4You tools in healthcare centers

participants' internet usage and their adoption of digital health screening tools and apps were examined across different countries. In Spain and Albania, all participants reported daily internet usage, with percentages of 100% and 90.9%, respectively. However, the use of digital health screening tools and apps was generally limited. In Greece, the majority of participants (74.3%) reported never using them, while 25.7% reported sometimes using them. In Bulgaria, all participants (100%) reported never using such tools, and in Spain, 47.1% reported never using them, while 41.2% reported sometimes using them. In Albania, the majority (45.5%) reported never using them, followed by 36.4% who reported usually using them. Regarding their health status, participants generally reported positive self-assessments. In Greece, the majority (60%) reported having very good health, with 28.6% reporting good health and 8.6% reporting fair health. In Bulgaria, the majority (50%) reported good health, followed by 37.5% reporting very good health and 12.5% reporting fair health. In Spain, the majority (47.1%) reported good health, while 29.4% reported fair health and 23.5% reported very good health. In Albania, the majority (54.5%) reported very good health, with 36.4% reporting good health and 9.1% reporting fair health. Participants expressed confidence in their ability to use the DigiCare4You system, if someone shows them how to use it. Greek and Albanian participants showed higher levels of enthusiasm compared to other regions. In Greece, the majority strongly agreed (68.6%), while in Bulgaria, the most common response was slight agreement (50%).

In Spain, participants leaned towards slight agreement (52.9%), and in Albania, the majority strongly agreed (72.7%) (Fig. 5).

Regarding the willingness to use the system Greek and Albanian participants showed higher enthusiasm. In Greece, the majority strongly agreed (42.9%), while in Bulgaria, the most common response was slight agreement (50%). In Spain, participants leaned towards slight agreement (47.1%), and in Albania, the majority strongly agreed (63.6%) (Fig. 6).

Concerning the interest of participants in receiving recommendations by the system about their health status overall participants indicated willingness in receiving

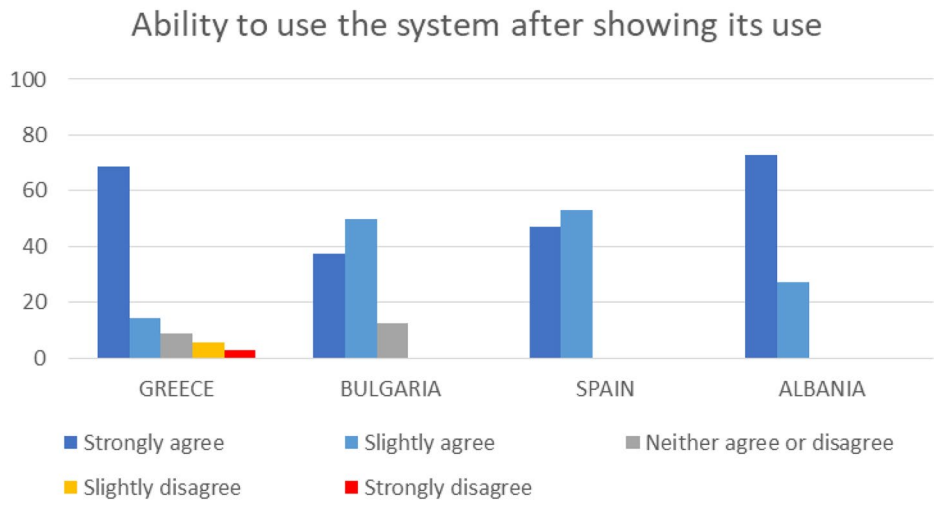

Fig. 5 Ability to use the DigiCare4You system

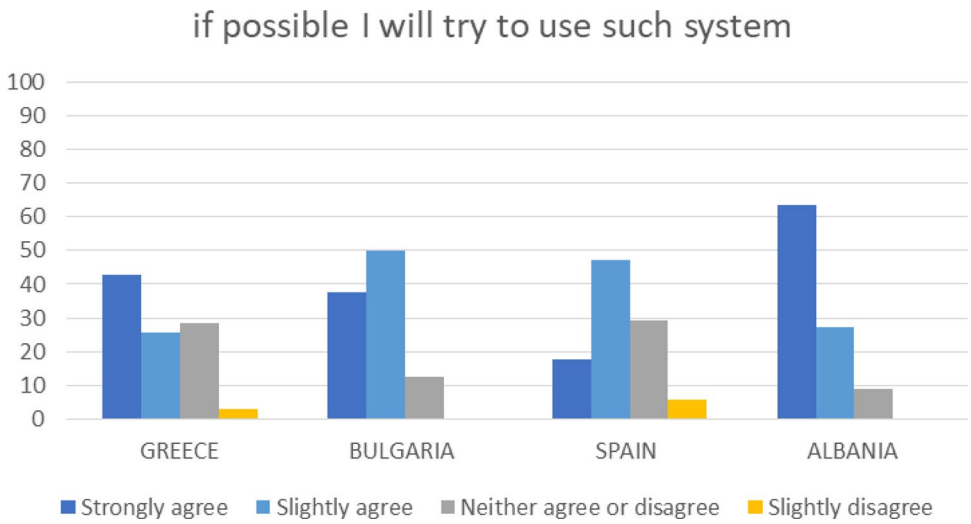

Fig. 6 Willingness to use the DigiCare4You system

recommendations by the system to change their health habits. In Greece, 51.4% strongly agree, Bulgaria has a 37.5% rate of strong agreement, while Spain and Albania have 35.3% and 63.6% strong agreement, respectively (Fig. 7).

Across the 4 regions, SUS scores ranged between 15 and 100 ($\mu = 68.06$, $\sigma = 18.77$) indicating overall good usability. Greek citizens evaluated the usability with $\mu = 73.5$, while Bulgarian citizens rated with $\mu = 66.2$. Spanish citizens and Albanian citizens, perceived the usability as marginal, with scores of $\mu = 61.32$ and $\mu = 62.5$, respectively.

4 Discussion

The present study aimed to evaluate the acceptance and usability of the DigiCare4You digital screening tool for diabetes in four European countries. The key findings of this study provide insights into the perceptions and attitudes of both implementers (health professionals/doctors) and citizens (patients) towards the digital screening tools and preventive interventions.

In terms of acceptance, most of the implementers perceived the screening tool as useful for their clinical practice. This aligns with previous research indicating the potential benefits of digital health screening tools in healthcare settings [31]. The tool was also perceived as easy to learn, and most of the implementers showed a positive intention to use it. However, it is worth noting that the familiarity with the use of digital screening tools across the participating regions was limited. This suggests the need for targeted implementation strategies and training programs to ensure optimal utilization.

The usability of the screening tool was assessed through the System Usability Scale (SUS). The average SUS score across the four countries was 73.9 for the implementers indicating satisfactory usability. Concerning the citizens'

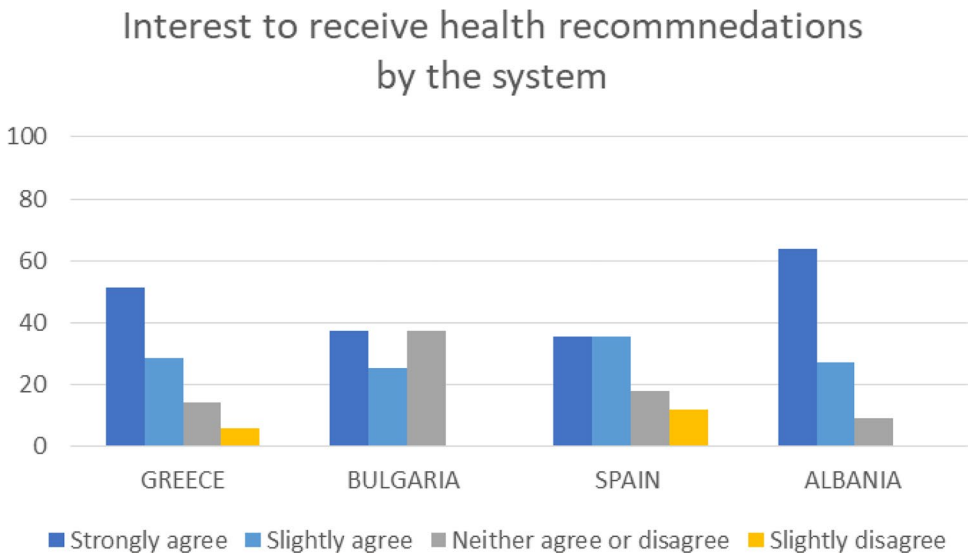

Fig. 7 Interest of participants in receiving recommendations by the system about their health status

assessment, the average SUS score of 68,06 also shows that the usability of the tool was above average (good usability is recognized to be one with a SUS score > 68). Overall, both scores indicate that the digital tools were generally perceived as easy to learn and use by both implementers and citizens. Notably, the usability scores were higher for Greece and Bulgaria, and lower for Spain and Albania. The variance in the SUS scores among the participants, reflects the different socio-economic conditions, mentalities towards digital solutions for health, different levels of digital readiness and certainly different public health systems in the four countries which participated in our study.

Comparisons with prior research highlight the consistency of our findings with existing literature regarding the acceptance and usability of digital health interventions. Nonetheless what needs to be emphasized is that our study sheds light on the considerable potential of these tools to drive significant transformations in clinical practice. For instance, one of the major changes anticipated, is the improved management of screening health information, which can lead to enhanced efficiency and accessibility of patient care in the community. However, the variations observed across regions underscore the importance of considering contextual factors, like the level of digital infrastructure and technology readiness, and implementation strategies should be tailored for settings like these. In areas with well-established digital infrastructure and high technology adoption rates, the implementation of digital health tools may be smoother and more readily accepted by both healthcare providers and patients. On the other hand, in regions with limited access to technology or lower digital literacy rates, special efforts may be required to ensure successful adoption and usability of digital health tools.

Interpreting the results reveals the potential of the DigiCare4You digital tool to positively impact healthcare screening services for citizens. The satisfactory acceptance and perceived usability indicate that these tools have the potential to enhance citizen preventive management of diabetes and facilitate lifestyle changes. The positive attitudes towards the use of the tools for prevention purposes suggest that they can effectively support healthcare professionals in providing individualized care in the community and empower citizens to take an active role in their health management.

Despite the overall positive findings, several limitations should be acknowledged. Firstly, the study involved a convenience sample, which may limit the generalizability of the results. Additionally, the study focused on perceptions and attitudes rather than actual behavior change or health outcomes. Future work will include the conduction of follow-up interviews to provide better understanding of the reception of the tool. Future research should explore the long-term effects of implementing the DigiCare4You tool and investigate its impact on patient health-related outcomes as well as healthcare professionals' performance and clinical practice.

5 Conclusions

The findings of this study demonstrate the overall acceptance and positive attitudes towards the DigiCare4You digital screening tool among implementers and citizens from different population groups across Europe. The tool was regarded to be usable and user-friendly, thereby holding the potential to enhance healthcare screening processes in the community. However, contextual factors such as digital readiness and variations across regions should be considered when implementing these tools. In conclusion, the acceptance of digital screening tools by citizens and healthcare professionals will pave the way for future digitally enabled screening

services in diabetes and contribute to the advancement of digital healthcare preventive interventions and patient care quality in the community.

6 DigiCare4You Study Group

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Declarations

Competing interests The authors declare no competing interests.

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