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Original Research

A Smartphone Application for Personalized Approach to Diabetic Eye Disease

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Abstract

Purpose: Develop a smart phone application to empower diabetic patients to understand their personal risk profile and individual risk factors for diabetic retinopathy.

Methods: An algorithm was developed to assess the individual risk profile of diabetic patients for sight threatening diabetic retinopathy. The algorithm was validated in 20,000 diabetic patients. A smart phone application was developed to present the application to individual patients.

Results: The algorithm predicts the onset of sight threatening diabetic retinopathy, i.e., diabetic macular edema and/or proliferative diabetic retinopathy with high accuracy. ROC analysis has AUC >0.8. A smart phone application has been released for iOS and android systems.

Conclusion: The smart phone application allows individual diabetic patients to see their own risk profile for sight threatening diabetic retinopathy. It allows each person to understand the impact of their personal risk factors and provides education and motivation for improvement in life style and treatment. This personalized medicine approach empowers each patient to be informed and active participants in his/her care.

Keywords

Diabetic Retinopathy; Information Technology; Personalized Medicine; Risk Profiling; Screening; Smart Phone Application

It is estimated that today, over 400 million persons have diabetes worldwide. This number is projected to exceed 600 million by 2030 [1-3]. Two-thirds of diabetic patients develop diabetic retinopathy within 20 years, and one-third develops sight-threatening retinopathy, where intervention is necessary to prevent sight loss [4-6]. The global epidemic of diabetes will become a global epidemic of blindness if preventive measures are not instituted. Leasher et al., [7] found that over 4 million diabetic individuals are visually impaired and this number has increased by 64% over the last 20 years.

Diabetic eye screening and appropriate preventive treatment are proven ways to reduce the risk of blindness from diabetes, figure 1 [4,5]. However, only a small minority of diabetic people in the world, perhaps 10% or less, have access to regular screening. The participation of patients with diabetes in eye screening programs must be increased around the world to prevent a wave of diabetic blindness in the future.

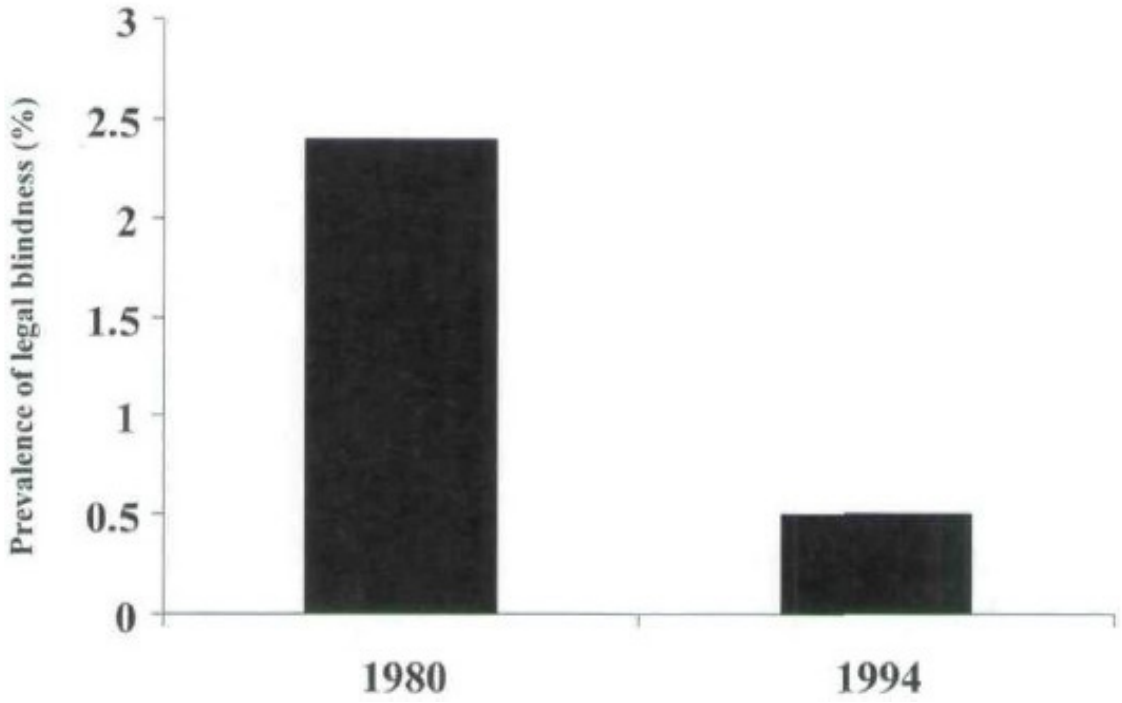

Figure 1: Prevalence of legal blindness in insulin dependent diabetics in Iceland in 1980 at the beginning of the screening program and again in 1994. The difference is statistically significant (p=0.02) Kristinsson et al., [4]. With permission from Acta Ophthalmologica.

Diabetic eye screening can be made more efficient and economically feasible. With annual eye screening for diabetic patients, only 2-3% has sight threatening retinopathy and is referred for treatment each year. Individualized risk assessment can improve this ratio. If screening frequency is based on the individual risk profile (i.e., each person's risk of developing sight-threatening retinopathy) the overall number of screening visits can be cut in half while catching all diabetic patients who need treatment (Figure 2). Risk profiling increases the screening frequency of high-risk patients, while low-risk patients are spared from unnecessary clinic visits [8-10]. With this approach the cost to individuals and society can be reduced by 40-70% while maintaining medical effectiveness. This makes systematic diabetic eye screening more economically feasible, also for poorer nations.

While the management of diabetic eye screening can be made more effective with the use of our algorithm, the goal of the Smartphone application and this report is different. The aim of the app is to empower the individual diabetic patient, help him/her to understand the personal risk profile and individual risk factors. Also, to educate the patient and motivate to improve risk profile and risk factors through life style changes and medical treatment.

Methods

Risk ehf., an Iceland-based company founded by academics and health-care providers with over 30 years' experience in screening for persons with diabetic retinopathy and treating diabetes, has designed a unique risk calculator that both evaluates individual risk for sight-threatening diabetic retinopathy and calculates appropriate screening intervals according to the risk profile.

Several large epidemiological studies on diabetic retinopathy have reported risk factors for diabetic retinopathy and documented the incremental increase in risk resulting from each risk factor [11-14]. These studies provide risk ratios for groups of patients. Our approach combines weighted risk factors for each diabetic individual into a mathematical algorithm, which calculated the individual risk for progression of retinopathy. The key is an individual or personal approach.

The Retina Risk calculator is a novel, clinically-validated decision support system [8-10]. The algorithm at the core of the Retina Risk calculator is based on extensive international research on risk factors known to affect the progression of diabetic retinopathy, such as duration of diabetes, gender, blood pressure levels and HbA1c. Glycated hemoglobin HbA1c reflects average blood glucose over 3 months. Clinical

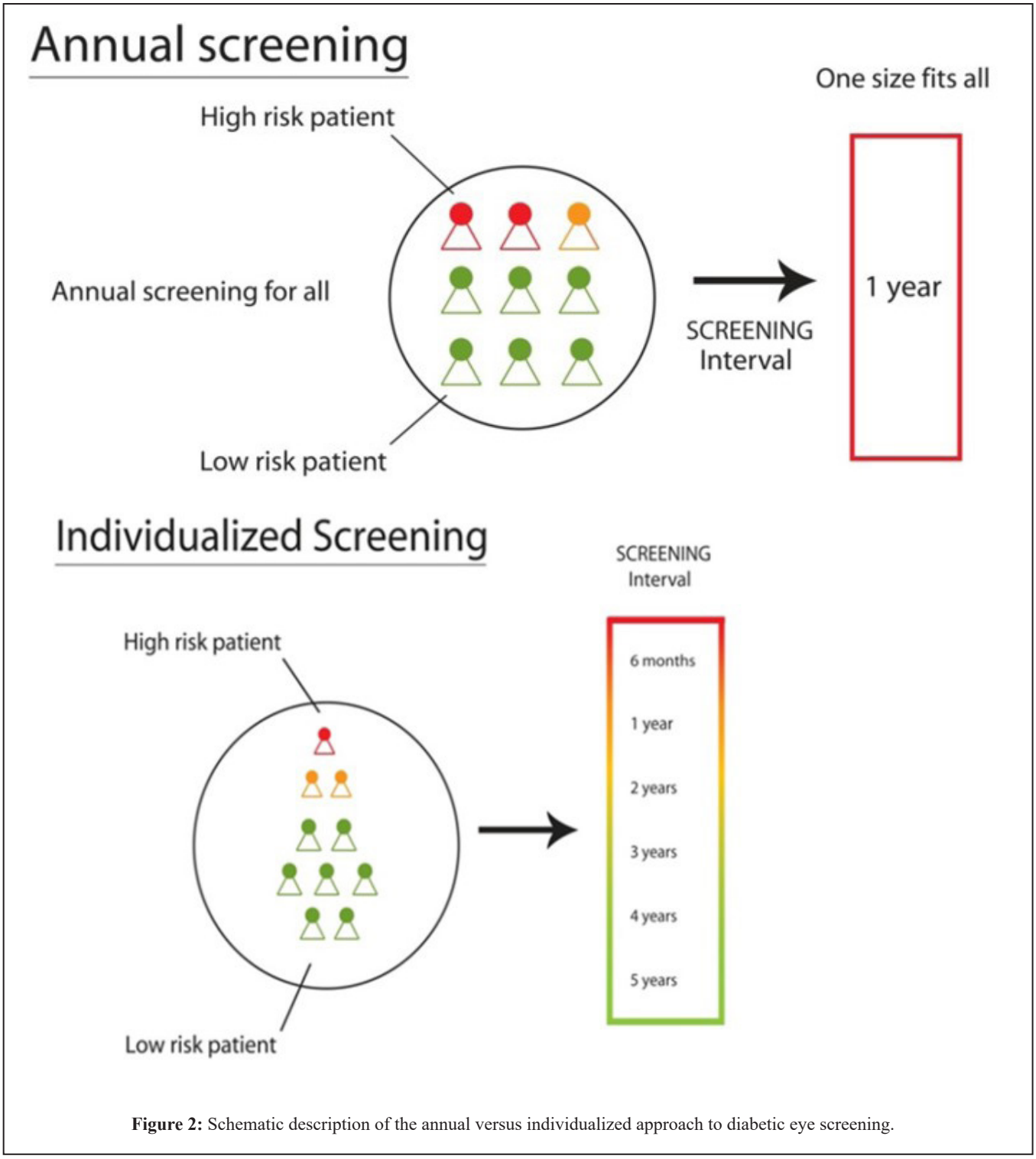

Figure 2: Schematic description of the annual versus individualized approach to diabetic eye screening.

validation in 20,000 diabetics is robust and the results have been published in several medical journals [8-10]. The Retina Risk calculator can serve patients, insurers, governments and individual clinicians and health professionals to streamline and make clinical management more focused and cost-effective.

Results

The predictive power of the algorithm is excellent. Lund et al., [10] test the prediction by the software to the actual experience in almost 10,000 diabetic individuals in England. Figure 3 show that the ROC curves predicting sight threatening retinopathy

had area under the curve above 0.8.

Risk Medical Solutions has launched the Retina Risk App, which is the first mobile application of its kind (Figures 4 and 5). The Retina Risk App allows persons with diabetes to assess in real-time their individualized risk for sight-threatening diabetic retinopathy, based on their risk profile, and to track the progression of the disease over time. It includes detailed guidelines and useful information on diabetes, diabetic retinopathy and improved self-care, which allows patients to better understand their condition and become active participants in their own wellness journey (Figure 5).

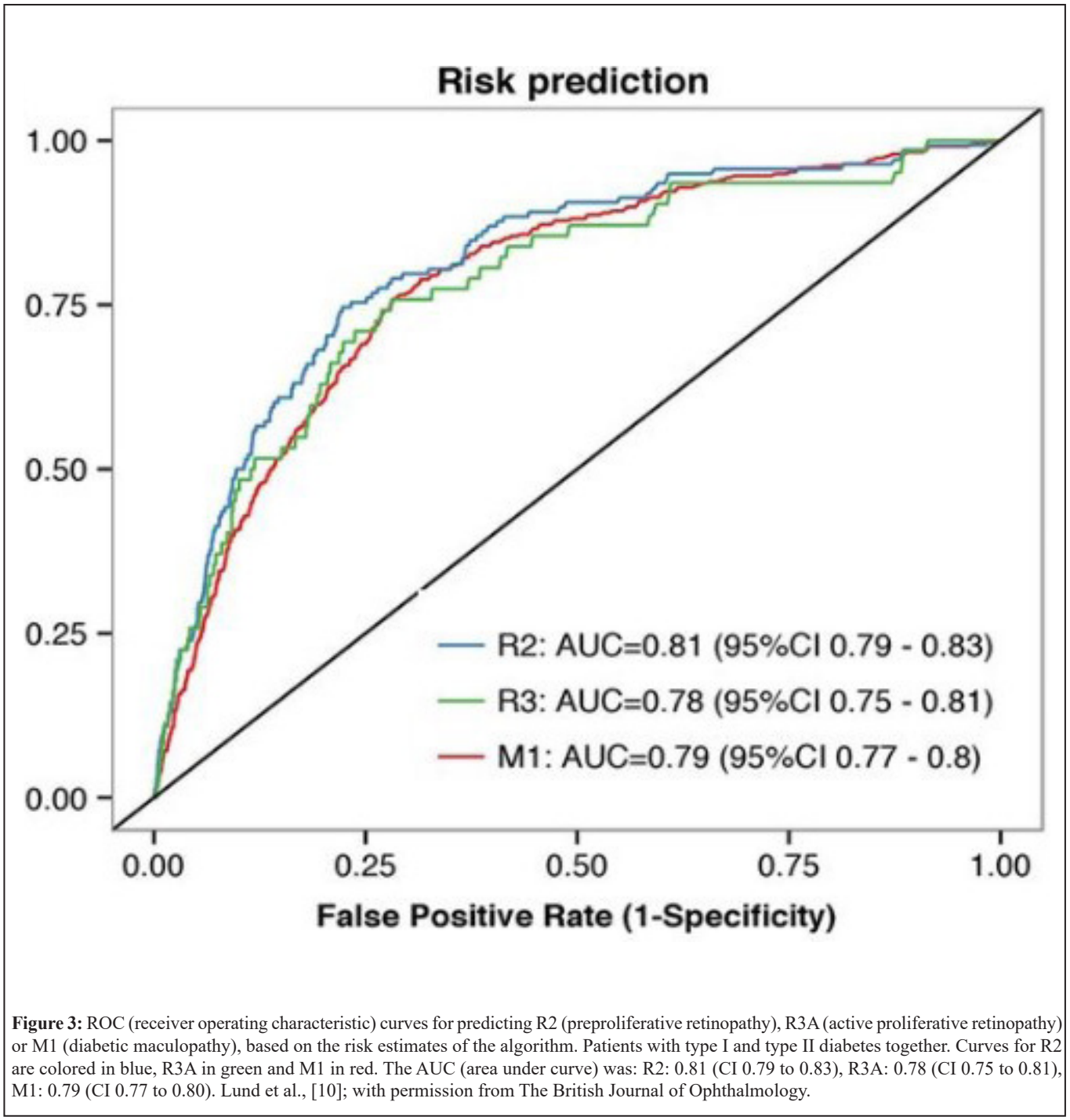

Figure 3: ROC (receiver operating characteristic) curves for predicting R2 (preproliferative retinopathy), R3A (active proliferative retinopathy) or M1 (diabetic maculopathy), based on the risk estimates of the algorithm. Patients with type I and type II diabetes together. Curves for R2 are colored in blue, R3A in green and M1 in red. The AUC (area under curve) was: R2: 0.81 (CI 0.79 to 0.83), R3A: 0.78 (CI 0.75 to 0.81), M1: 0.79 (CI 0.77 to 0.80). Lund et al., [10]; with permission from The British Journal of Ophthalmology.

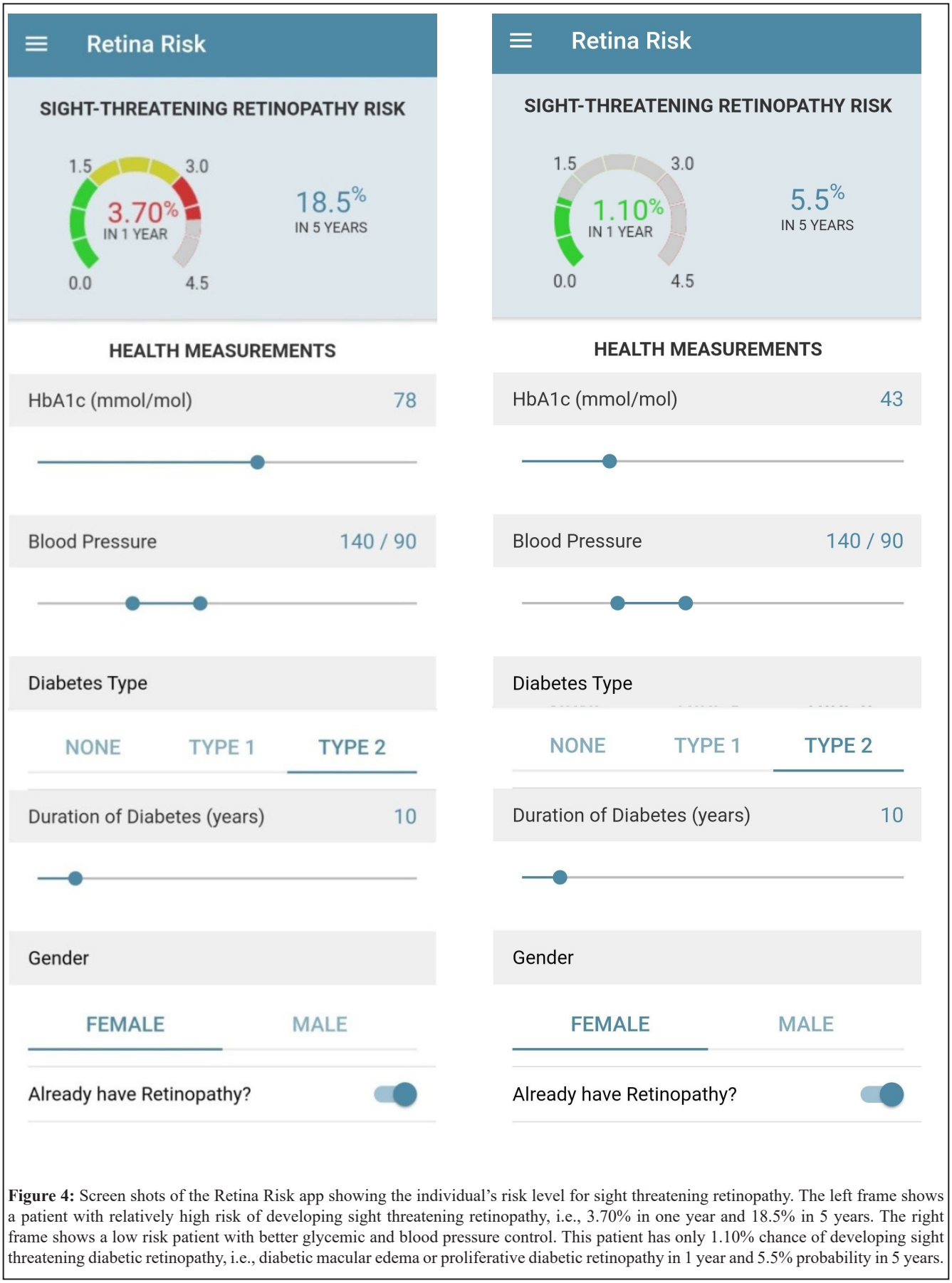

Figure 4: Screen shots of the Retina Risk app showing the individual's risk level for sight threatening retinopathy. The left frame shows a patient with relatively high risk of developing sight threatening retinopathy, i.e., 3.70% in one year and 18.5% in 5 years. The right frame shows a low risk patient with better glycemic and blood pressure control. This patient has only 1.10% chance of developing sight threatening diabetic retinopathy, i.e., diabetic macular edema or proliferative diabetic retinopathy in 1 year and 5.5% probability in 5 years.

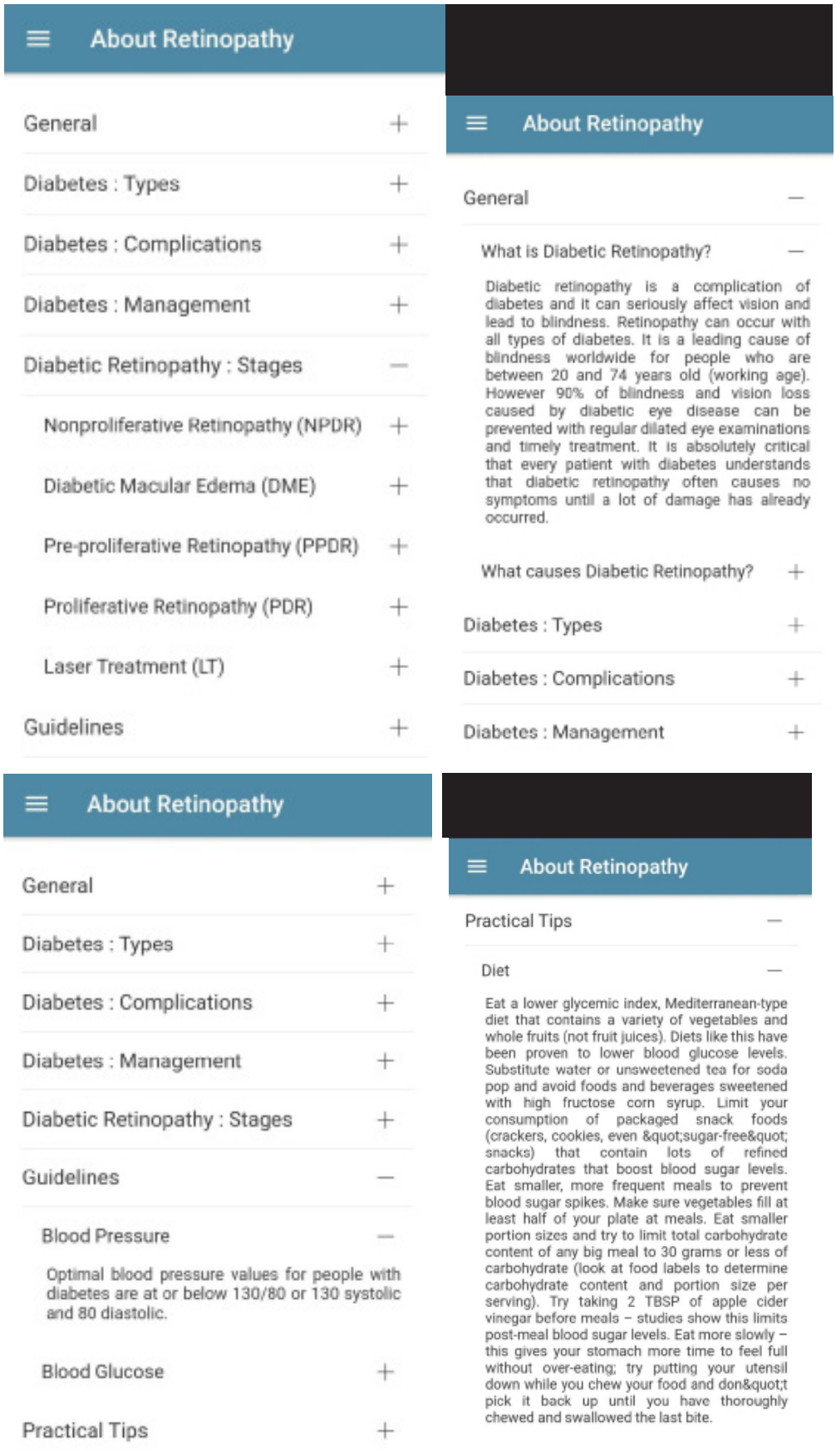

Figure 5: Selected frames from the educational part of the application. Patients have access to a variety of educational and motivating information that is relevant to their personal clinical situation and risk profile.

Conclusion

The Retina Risk App empowers persons with diabetes to become more involved in their health care decision-making. It supports patient self-management by demonstrating the importance of regular eye examinations and seeking timely medical assistance. It motivates persons with diabetes to become more responsible and better-informed patients. The App's easy-to-visualize, effective and efficient patient education tools vividly demonstrate how improvement of modifiable risk factors (e.g., blood glucose, HbA1c, blood pressure) could significantly lower the risk of potentially blinding diabetic eye disease and expensive interventions.

Patients can update their risk profile whenever they acquire new information about their risk factors. It is important that this be done whenever there is a change in lifestyle, measured risk factors or health situation that may change risk factors and at least annually.

The Retina Risk App is available free of charge for both Android and iOS and can be a game-changer in ensuring that people with diabetes seek eye-screening in a timely manner. The app does not store any health-related data. The clinical values can be inserted manually but where electronic health records are available, the access is facilitated through the digi.me platform. The Retina Risk App is an important step towards personalized healthcare and empowerment of patients.

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