Developing Artificial Intelligence Model for Prediction of Diabetic Retinopathy and Delivering in a real-world Local Context: BP Eye Foundation's Perspective

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The International Council of Ophthalmology guideline suggests immediate examination for diabetic retinopathy (DR) at the time of diagnosis of type 2 diabetes and within five years of diagnosis of type 1 diabetes. A meta-analysis shows the prevalence of diabetes to be 8.5 % in Nepal (Shrestha N et al, 2020). The estimated national hospital-based prevalence of DR (19.4%), proliferative DR (4.6%), and diabetic macular edema (6.9%) reflects the huge magnitude of vision impairment in Nepal (Takkar et al, 2021). DR was reported as a cause of visual impairment in 10% (2.8M) and blindness in 7.89% (2.2M) in 2010 which has doubled in less than a decade (Upadhyay MP et al, 2011). Given the low number of ophthalmologists and retina specialists in Nepal, many of these patients are missing DR examinations. Artificial intelligence (AI)- enabled model for predicting DR may be a viable option for screening diabetic patients in the future in Nepal.

A technological miracle stands out in this age of progress as a ray of hope for millions of people: Artificial intelligence. Imagine a scenario in which an algorithm can examine the inner workings of the human eye, not only identifying but also accurately forecasting DR. We're glad you're here at the cutting edge of AI-driven disease prediction, where our goal of a happier, healthier future isn't just a pipe dream anymore. It's a tangible reality. AI is an innovative discipline within computer science that enables computers to perform tasks usually done by humans when they (computers) are trained, and it is like mimicking human intelligence by a machine. AI has been successful in ophthalmology as diagnoses mostly rely on photography. Photography is frequently used in ophthalmology and so in diabetic retinopathy. BP Eye Foundation, CHEERS Hospital, Bhaktapur has successfully developed its own AI model in the prediction of DR based on a deep-learning

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model with Inception-v3 architecture. It has good accuracy with a sensitivity of 98.57%, a specificity of 92.97%, and an area under the curve (AUC) of 0.988 (Upadhyay et al, 2022). We have applied our AI system to real patients from outreach and outpatient patients within a base hospital to see how it predicts DR in a local context. AI automatically graded the disease into no DR or different stages of DR. The question is what accuracy markers should be considered appropriate to launch AI in the community screening. To rely on AI to predict any disease and for a successful screening program in the community, its sensitivity and specificity should be above 80 % and 95 % respectively according to National Health Service guidelines (Lois et al., 2021). Otherwise, low-sensitivity algorithms will leave many patients with DR in the community undiagnosed. Similarly, low specificity will likely result in false positive cases and diabetic patients with normal retinas will be referred to ophthalmologists. This will subsequently increase the load of ophthalmologists for consultation of unnecessary referrals. The anxiety of patients, transport cost and time to visit an ophthalmologist, and mistrust of patients with the health care systems are other challenges of AI systems. There is more than sensitivity specificity to the applicability of the AI model which is cost.

In our experience, the quality of the fundus picture matters most in interpreting AI-enabled DR grading. While comparing the quality of fundus images, those taken after dilating pupils will be better than fundus images taken without dilating. Targeted pupil dilation is another approach where the pupil is dilated just enough to take a fundus picture. So, the patient need not have to wait until full pupillary dilatation, and the blurry effect also may not bother much. Tips for capturing a good-quality image include several steps. Firstly, explaining to the patient to expect a flash of light or fix on the target is very important. If the person has difficulty focusing on a fixed target, occlusion of the other eye is required. Secondly, ensure that both the patient and the photographer are in a comfortable position. Asking the patient to blink and keep eyes wide open until the image is captured or sometimes, lifting or opening the eyelid by a photographer may be required. Thirdly, make sure the camera lens is clean from fingerprints or dust. The final note is a photograph taken in the darkroom (Sharon, 2023). It is recommended to take two fundus pictures, one macula centered, and the other disc centered. The English National diabetic eye screening program (NDESP) approved camera's image has a field of 45 degrees horizontal and vertical with a resolution of at least 12 megapixels for each capture. A combination of the macula and disc-centered images cover a field of 60 degrees horizontal x 45 degrees vertical (NHS 2019).

Telehealth and AI have already been proven as a cost-effective method for high-income countries, however, it has not stood the test of evidence in developing countries (Cleland et al, 2023). This is something we would like to pursue in the future. While analyzing costs from the healthcare provider's perspective, purchasing of hardware and software, and maintenance costs need to be considered (He et al, 2019). Purchasing a portable fundus camera is far cheaper, yet the quality is not inferior to a desktop fundus camera, however the battery life and wear and tear are more likely with a portable fundus camera. Recently, the smartphone-based fundus imaging systems used by technicians in Retinopathy of prematurity screening were proven to be highly sensitive (Young et al, 2023). It seems that the cost of fundus imaging for DR detection with smartphones may even be less compared to portable fundus cameras soon. Similarly, from the perspective of the community, we must analyze how much is saved for the community like transport costs, appointments, unpaid leave while visiting ophthalmic consultants, and treatment costs in the tertiary care center. Societal costs are difficult to measure, and we must rely on the rough estimation of costs. Moreover, these are analyzed only from the provider's perspective. AI has reduced human effort and time. While seeing the value per encounter, it was assumed to save ten minutes per fundus picture grading by an ophthalmologist. If we consider fundus reading by graders other than retina specialists like general ophthalmologists, optometrists, and other trained graders again the cost savings will be greater (Lee et al., 2021). More than saving money, saving time is crucial as most of the ophthalmologists in our context are multitasking like clinical workups, surgery, mentoring, and supervision. For clinicians, the cost of care is even more important than the effectiveness of a new technology for an engineer. However, all new technologies become less expensive with time. Our observation suggests that AI-based screening could be cost-effective compared with conventional ophthalmologist and grader-driven screening and holds great hope to be another option for DR screening in the unreached part of Nepal. It provides DR status immediately and reduces the load on the health system.

Since our AI data on DR was a pilot study with small national data and considering the need for big data for AI, we would like to recommend a collaborative national multi-institutional study. Future studies should explore the economic impact of AI implementation in the DR evaluation throughout the patient's life, providing a clearer view of AI's economic sustainability in DR screening. Certifying the photographers and training and retraining would be another step in the future as AI-enabled diagnoses depend on the quality of the fundus picture.

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