Journal of Research in Nursing and Midwifery

J. Res. Nurs. Midwifery 2020, 9:3

Short Communication

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An AI-based diabetic retinopathy screening system and its use in real-world clinical settings in Australia and Singapore

The World Health Organization announced in 2018 that 422 million people worldwide suffer from diabetes mellitus. The projected impact of vision impairment and blindness caused by Diabetic Retinopathy (DR) will result in significant public health and economic consequences. DR is preventable and treatable if detected early through an annual eye screening. However, screening rates are low globally due to a paucity of trained eye-health professionals in developing countries and in rural or remote areas of developed countries. Based on the research from CSIRO Australian e-Health Research Centre, TeleMedC group commercialized an AIbased Diabetic Retinopathy screening system-DR grader, an automated DR grading and preliminary referral decision support tool for patients with diabetes. The cloud-based tele-ophthalmology system has the functionalities of: (1) Deep learning based image quality assessment tool; (2) Deep learning based DR "disease/no disease" grading for color retinal images; (3) DR lesion localization and DR level indication; (4) Preliminary report of patient referral/no referral decision; and (5) DR disease audit by eye experts and developing patient referral pathway. DR grader has been deployed in a GP Super clinic at Midland, Western Australia from December 2016 onwards.

Keywords

Cortisol, Alzheimer's disease, Diabetes, Folic Acid

Back Ground

Diabetic retinopathy (DR) is a microvascular complication of diabetes mellitus, leading to progressive damage to the retina. DR has been deemed as a global public health problem, and diabetes-related visual impairment requires early detection to be prevented. From epidemiology studies, approxi-mately one in three persons with diabetes has signs of DR,and a third of these might suffer from vision-threatening reti-nopathy, defined as a severe non-proliferative diabetic retinop-athy or diabetic maculae edema (DME). Recently, DRincidence has been estimated to range from 2.2 to 12.7% and remains a leading cause of vision loss in many developedcountries, particularly among the adult working-age popula-tion. Management and identification of patients at risk for DRcondition by risk stratification are crucial.To prevent development and progression of DR condition,regular follow-ups are

Note: This work is partly presented at 7th World Congress on Public Health, Nutrition & Epidemiology (May 15-16, 2019 Singapore)

required and DR screening programshave long been recommended for individuals with diabetes. The international Council of Ophthalmology (ICO) hasinitiated a comprehensive guide for physicians and ophthal-mologists incorporating evidence-based principles with real-world experience with recommendations for diagnosis, defi-nition, screening and re-ferral criteria, follow-up, and manage-ment options. However, since the implementation and main-tenance of comprehensive and effective programs require sub-stantial resources, DR screening is not widely practiced world-wide as a national program, and many patients with diabetesare unaware of their risk of DR and other related complica-tions. AI Applica-tion in HealthcareOver the past decades, artificial intelligence (AI) has explodedinto the scientific consciousness with breakthroughs that aresparkling increasing interests among computer science andmedical communities. AI is a branch of computer science inwhich ma-chines mimic the cognitive function of human mind,making decisions that were regarded to require human cogni-tion. Since the mid-twentieth century, researchers have iden-tified the need for support systems to process the increasingamounts of clinical data required to make clinical decisions.Machine learning (ML) algorithms empower computers thatsug-gest diagnosis or clinical management without direct hu-man intervention, by extracting clinically relevant informationfrom medical data. With recent progress in digitized data acquisition and com-puting infrastructures, driven by the successful applications ofAI and by harnessing the computation power of graphics pro-cessing units (GPU), deep learning (DL) has emerged as anattractive ML method within AI. DL was inspired by theoperation of the human brain in processing data and involvesmodel architectures called convolutional neural networks(CNN). CNNs operate on the raw data to learn useful features,identifying significant patterns from training datasets. DLhas shown substantial potential in medical imaging. These technologies have achieved robust diagnostic perfor-mance in detecting major medical conditions from severalmedical specialties including radiology, dermatol-ogy, ophthalmology, pathology, and pediat-ric diseases. DL-based tool impact is manifold: for clini-cians, as image interpretation assistance; for health systems, asworkflow improve-ment; and for patients, in terms of morereliable diagnosis. Although DL-based technologies in medicine are advanc-ing rapidly and multiple retrospective studies have demon-strated that AI can perform on par with clinical experts, mostof these tools have not been evaluated in controlled clinicalprospective studies. The real-world implementationinto patient-care settings is hindered by several practical is-sues, such as algorithm transparency, records sharing, privacy,and data standardization. In addition, DL algorithms are ex-tremely 'data hungry'and large resources of medical data arerequired to conduct large-scale studies. However, giventhe rapid and impressive progress of AI technologies, themedical commu-nity is cautiously optimistic that AI mightenable higher-capacity and lower-cost care in reality In the field of ophthalmology, AI using ML and DL has beenbroadly studied. Over the past few years, severalapplications in fundus photography, optical coherence tomog-raphy (OCT), and visual fields have shown clinically accept-able performance. Specifically, ro-bust classification perfor-mance in detection of age-related macular degeneration(AMD), glaucoma, and retinopathy of pre-maturity has been achieved from retinal fundus pho-to-graphs. Promising diagnostic accuracies on par with clinicalexperts have also been ob-tained for DR detection. DL in ocular imaging has been shown to be effective whenapplied to OCT for AMD automated detection, mac-ular telangiectasia automated detection, visual acuity out-comes, and DME-automated segmentation and de-tection. DL techniques have also been successfully applied for the detection and quantification of different typesof macular fluid from OCT images. In addition, perfor-mance comparable to human experts in referral triage deci-sions and classification of 10 OCT pathologies with DL strat-egies have been attained. DL has also been applied tonon-traditional task on retinal images such to estimate refrac-tive error, quantity of anterior chamber inflammatorycells, forecast future Humphrey visual fields, andpredict cardiovascular risk factors.

Results: Results of this implementation were published in a JAMA Network Open article (September 2018) evaluated a total of 291 patients. The system correctly identified all 12 patients with true disease (sensitivity 100%) and misclassified 23 patients as having disease (specificity 92%). The DR grader has been undergoing testing in Singapore since early 2018 at the Department of Ophthalmology, National University Hospital and in 30 GP clinics with similar or better preliminary results pending publication.

Conclusion: The AI-based DR screening system provides quick DR patient referral decision support in the primary care setting. It benefits patients from poorly-resourced and underserved remote areas for its low cost, time savings and high patient acceptability. The system was well received by primary care providers.