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Review Article

Digital retinopathy photography: the way forward for standardizing retinal screening in patients living with diabetes: an overview of the key challenges to care delivery in Qatar

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ABSTRACT

The incidence of diabetes is rising globally with Qatar being ranked as the 3rd highest country for the prevalence of diabetes in the Middle East and North African (MENA) region. Diabetic retinopathy (DR) is the main cause of sight-threatening complications of diabetes. Significant advances in screening and treatment for DR have emerged in the last few decades with a strong impact on the accuracy and effectiveness of screening. DR being a preventable cause of blindness with early detection and interventions like laser photocoagulation and anti-vascular endothelial growth factor (anti-VEGF) treatments makes it imperative to invest in early recognition and treatment for DR. Globally screening is done by direct/indirect ophthalmoscopy or retinal photography with huge variations in early diagnosis. Studies have revealed the superiority of three-field retinal photography when compared to direct ophthalmoscopy, for DR screening, even if performed by an experienced ophthalmologist. The two most sensitive means of detection at present are digital retinal imaging and slit lamp examination post mydriasis. Both modalities require assessment by trained personnel. Digital retinal photography is extremely quick, allows the creation of permanent records and with the advent of semiautomatic nonmydriatic cameras, requires less skill as compared to the use of a slit lamp. Hence, should digital retinal photography be a preferred standardised method for retinal screening in Qatar?

Keywords: Diabetes mellitus, DR screening, Fundal photography, Slit lamp

INTRODUCTION

Diabetes is becoming a global epidemic with 451 million people living with diabetes in 2017 with an estimated increase to 693 million by 2045 as reported by the International Diabetes Federation.[1] DR remains the main cause of vision loss and preventable blindness in adults aged 20-74 years."[2] DR is a microvascular complication of diabetes. It is an ischaemic ocular disease characterised by retinal neurodegeneration and the vascular formation of retinal microaneurysms and haemorrhages. Hypoxia and the associated release of vascular endothelial growth factor (VEGF) are likely to lead to proliferative DR with the formation of fragile retinal vessels at the vitreous surface. This is a sight-threatening complication that may lead to vitreous haemorrhages and retinal detachment. DR as a complication is seen in patients with long-duration of diabetes or poorly controlled diabetes.

Globally in 2010, 191 million people were visually impaired, and 32.4 million people were reported to be blind. Out of this 3.7 million were visually impaired and 0.8 million were blind due to DR, an increase of 27% and 4% in the last two decades.[3] The Vision Loss Expert Group of the global burden of disease study also reports the crude prevalence of visual impairment and blindness caused by DR increased significantly between 1990 and 2015.[4] DR has been found to be the fifth leading cause of blindness and moderate to severe vision impairment in

adults over the age of 50.[5] This is thought to be due to increased prevalence of diabetes in low and middle-income countries. Prevalence in the last decade or two for the rate of less severe non-proliferative DR in the United States is declining.[6] This is supported by the observation of early diagnosis and prompt management of sight-threatening DR. A systematic review and meta-analysis by Wong et al also showed a significant decline in the prevalence of DR in developed countries such as the US, Australia, and European countries like the United Kingdom, from 1975 to 2008.[7] This has been attributed to the increased awareness of DR risk factors, better glycaemic control, and access to screening programs in the community.[7]

As the global population is increasing at a steady rate with increasing life span of people living with diabetes and having a more sedentary lifestyle changes leading to an ever-higher risk of developing diabetes, it is reasonable to expect an ever-increasing burden of DR. A meta-analysis by Teo et al projects the number of people with DR in the MENA region by 2045 will be around 160.5 million.[8] It is therefore in the interest of all stakeholders in the MENA region to look at innovative ways of managing and preventing diabetes and optimizing effective screening programs in the community for reducing DR.

Evidence has established the role of early diagnosis, addressing risk factors, and timely intervention in reducing the risk of blindness from this microvascular complication.[9] Some studies claim diabetes-related visual impairment can be prevented in 98% through early detection and prompt treatment of DR.[10] At present, it is estimated that 70% of diabetes occurs in middle-income and low-income countries where resources for systematic screening are scanty. “Patients with severe levels of DR are reported to have poorer quality of life and reduced levels of physical, emotional, and social well-being, and they utilize more health care resources.”[11] The vast majority of patients with early disease are asymptomatic hence systematic screening programs are required to ensure timely follow-up and intervention.

DR SCREENING CRITERIA

DR screening fulfils the criteria for screening as per Wilson and Jungner's principles.[12] These include the following: The condition should be an important health problem, there should be an acceptable treatment for patients with recognized disease and the prognosis should be favourably adjusted if this is given at a presymptomatic stage, facilities for diagnosis and treatment should be available, a natural history of the condition, a recognizable latent phase should exist and be adequately understood, a suitable and acceptable test can be performed and the cost of case finding should be economically suitable for the society.

The advent of treatment options, namely, laser photocoagulation and anti-vascular endothelial growth factor (anti-VEGF) treatments makes a strong case for early diagnosis and treatment. All international guidelines agree on early diagnosis however as the landscape of the disease is changing worldwide, there is a greater disease burden in developing countries where there is a need for nationwide screening programs to ensure timely detection. Unfortunately, there is a lack of epidemiological data in countries that are thought to be at the center of the diabetes epidemic such as Asia and Africa.

In 2007, WHO published a report on “Vision 2020 the right to sight-global initiative for the elimination of avoidable blindness” which recommended that countries with diabetes mellitus as a public health problem should adopt the public health approach to address DR.[13] Some of the strategies for DR detection that are highlighted in this report are as follows: Educating patients regarding eye complications, early detection of DR through providing access to early screening to assess for possible eye complications in patients with diagnosed diabetes mellitus, ensuring the accuracy of methods used for detecting the presence or severity of DR, provide comprehensive screening at adequate locations close to patient needs and train adequate staff in the use of specific photography systems.

Worldwide, screening for DR is an important issue. However, screening and prompt treatment of diabetic retinopathy are not considered to be a top priority for many countries. The increasing prevalence of patients with diabetes-related ocular complications is a healthcare challenge both for the developed and developing world. The growing epidemic in countries with low resources suggests that there is a proportion of the population who may not be able to access treatment promptly with potentially life-changing consequences.

DR screening is performed in many ways worldwide by healthcare professionals like optometrists, ophthalmologists, screening technicians, and clinical photographers: Direct/Indirect ophthalmoscopy, dilated slit lamp bio-microscopy examination with hand-held lens, mydriatic or non-mydriatic retinal photography, tele-retinal screening ± deep learning systems analysis and retinal video recording.

The Liverpool diabetic eye study revealed the superiority of three-field retinal photography when compared to direct ophthalmoscopy, for DR screening, even if performed by an experienced ophthalmologist.[14] The slit lamp examination does have good sensitivity and specificity for the identification of referable disease; however, its use is limited in low-resource environments, the availability of trained staff, and the need for mydriasis.

The two most sensitive means of detection at present are digital retinal imaging and slit lamp examination post mydriasis. Both modalities require assessment by trained personnel. Digital retinal photography is extremely quick, allows the creation of permanent records and with the advent of semiautomatic nonmydriatic cameras, requires less skill as compared to the use of a slit lamp. Hence, it is the preferred method for retinal screening. A study by Liew, has reported mydriatics-induced acute angle-closure attacks in 6 in 20,000 Caucasians with a slightly increased possibility among the Asian populations due to the difference in eye anatomy.[15] Non-mydriatic retinal photography may be preferable and seems to be a popular screening technique in the primary care setting however, it has a higher technical failure rate.

Fundal photography has made great advances since the 1970s with improvements in retinal imaging as compared to the previous gold standard of film-based seven-field photography used in the early treatment of DR Study.[16] This protocol is unsuitable for screening due to time constraints and cost implications. Since the 1970s, digital retinal photography has allowed improved quality as well as the use of telemedicine programs for retinopathy screening programs.

Across guidelines, there is variation in the accepted criteria for the use of digital imaging. The national institute of clinical excellence (NICE) has suggested a minimum of 80% sensitivity, 95% specificity, and a failure rate of 5%. This contrasts with the National Health and Medical Research Council (NHMRC), which suggested a minimum sensitivity of 60%, with an assumption of an increase in pick-up rate with repeated testing.[17] The British diabetes association has recommended that screening procedures should be able to provide 80% sensitivity and 95% specificity for referable diseases.[18]

NICE, New Zealand and the World Health Organisation (WHO) recommend two or three field dilated digital fundus imaging. Evidence suggests that digital photography post mydriasis, with a sensitivity of 87-97% and specificity of 83-92%, is the most effective screening strategy for sight-threatening disease.[19] This was supplemented by evidence that multifield photography was more sensitive as compared to single-field imaging. This applies to both mydriatic as well as nonmydriatic imaging.[17] However, there are limitations such as time constraints, training, and patient collaboration.

Due to the above limitations, some guidelines have adopted the use of nonmydriatic retinal cameras such as NHMRC. There is evidence to suggest that high-quality, single field, nonmydriatic photography has a 71-84% sensitivity and 93-98% specificity for disease warranting referral.[17] Data suggests that nonmydriatic photography may be a suitable means of screening in rural areas where essentially the decision to refer or not is required. This would allow a greater proportion of the population to be screened.[19]

Nearly in every industrialized country, DR is the leading cause of blindness in the working-age population. The United Kingdom has managed to overcome this by a highly effective and systematic retinal screening program using digital retinal photography and telemedicine. Launched in 2003 for all patients with diabetes above the age of 12 years, the program reached national coverage after 5 years. Digital images are collected in the community by trained technicians and forwarded using telemedicine to hierarchical graders with onward referrals to ophthalmologists if required. The screening program has achieved 80% coverage and in 2010 showed significant change to the landscape of diabetic ocular complications where, for the first time, diabetic retinopathy was no longer the main cause of blindness in the country.[20]

Digital retinal photography has facilitated retinopathy screening programs not only in the UK but also in Ireland, and regional programs in the US and other European countries.[21] "Digital retinal photography is considered to be the most effective diabetic retinopathy screening method, but many countries cannot afford to buy cameras to screen everyone who has diabetes."[22] The use of cheap handheld devices does hold some promise for rural areas where screening may be particularly problematic. However, these have not been found to be an effective reliable screening method to date. The future does hold roles for artificial intelligence (AI) where machines use deep learning algorithms to process and grade images. There is a huge projected cost saving for this technology. Improvements in digital imaging alongside AI systems may help facilitate screening. At present, this seems to be academic for low to middle-income countries.

Ultra-wide-field fundus imaging technology has also been implemented recently in DR screening. A single photograph can provide a 200 wide-field image by combining an ellipsoid mirror with a scanning laser ophthalmoscope. This is a newer more promising modality at improving the accuracy of detecting more peripheral lesions with an overall increase in accuracy by 15% to 17%, lower technical failure rate by 3%, and quicker image evaluation time.[23]

Tele-retinal screening involves digital retinal imaging with remote image interpretation. This has been successfully carried out in various countries like Australia, India, the United States, and the United Kingdom.[24,25] Furthermore, the use of digital retinal photography with offsite grading, using telemedicine, is more cost-effective when compared with ophthalmoscopy by a mobile ophthalmologist.[21] In Singapore, the national screening program-The Singapore Integrated Diabetic Retinopathy Program (SiDRP) is set up with this telemedicine model with a centralised

reading centre based at Singapore eye research institute. The retinal images are sent to this central database and read within an hour by professional graders and reported back to the primary care physicians for timely referral to an ophthalmologist for the warranted patients. Nguyen's study in 2016 shows how cost-effective this program is for Singapore.[26]

Artificial intelligence is increasingly catching on to ideas of further development in technologies. SiDRP has also tested a deep-learning system that relies on a machine-learning technique that allows a retinal image to be read by a machine to produce a comparable diagnostic performance to human graders for the detection of DR. A cost analysis suggests a semi-automated model combining the deep-learning system with human grader assessment achieved the most economic return for screening diabetic retinopathy rather than the standard grading by human graders alone or total dependence on the deep learning system grading independently. While technologies have shown immense advancement, implementation of these technologies are slow and sparse.[26]

Globally, there is no standardised way to screen for diabetic retinopathy. Public health strategies to control visual disabilities due to DR in the Eastern Mediterranean region (EMR) have been accepted screening for diabetic retinopathy as a priority by member countries of EMR, however, implementation is still a great challenge. There are limitations in the public health approach to DR in comparison to that for cataracts.[27]

Bahrain, a neighbouring country to Qatar, has had an integrated diabetic retinopathy screening program that has used telemedicine for detecting DR since 2003 when it was first piloted and in 2008 it was implemented as a national screening program with a central ophthalmological reading centre.[28]

Currently, there is no definitive answer for developing countries where screening is more challenging due to low resources, lack of scale, and geographical isolation.

The state of Qatar, one of the richest countries in the Gulf is identified among the countries with one of the highest prevalence of diabetes mellitus among the adult Qatari population at a rate of 16.7%.[29] There is no register for diagnosed diabetes patients and hence, no direct referral system for screening all patients with diabetes for DR. There is a dual system with half of Qatar's population registered at the government's primary health care corporation while the other half of the population tends to attend private healthcare services. This makes it difficult to access the true prevalence of diabetes and its complications.

PREVENTING DIABETES TOGETHER

The ministry of public health (MoPH) of Qatar has launched a campaign to address the growing epidemic of diabetes by proposing a Qatar National Diabetes Strategy (QNDS) with a slogan of "preventing diabetes together".[30] This aims to reduce the incidence of diabetes and its complications by bringing awareness of risk factors and guiding behavioral changes for persons with diabetes. In a recent study by Al-Thani et al, in their study in 2019 showed that that the majority of diabetic patients attending hospital and primary care clinics for the management of diabetes are satisfied with the guidance they have received from physicians for managing their diabetes.[31] However, a larger study in 2022 looked at knowledge, attitudes, and practice toward diabetes among Qatar's residents and nationals suggests a low level of knowledge of diabetes-related risk factors.[32] This study highlights the need to initiate an effective mass campaign including the use of social media and digital channels which may increase the knowledge about diabetes prevention among the younger population. Reducing the prevalence of diabetes will reduce the prevalence of diabetes complications.

In Qatar, DR represents approximately 25% of cases assessed in secondary care.[33] Elshafei et al in 2011 also showed the prevalence of DR among diagnosed diabetic patients in Qatar was 23.5%. They noted the longer duration of diabetes and poor diabetic control were among the main reasons for DR development.[34]

Community screening for DR in Qatar's Primary Care Health Centres is currently being carried out by ophthalmologists using both direct and indirect ophthalmoscopy post-mydriasis. When indicated, patients are referred for optical coherence tomography (OCT) imaging to secondary care. There is a growing concern over the prevalence of diabetes within Qatar. This poses a significant strain on the current workforce where there are a limited number of opthalmologists available at the primary care level.

Qatar's population includes a significant percentage of marginalized groups, with poor health literacy, who frequently miss their screening appointments and tend to disengage with services due to multiple factors. The use of digital retinal photography which could allow screening at the point of care may reduce the strain on the current workforce and allow opportunistic testing for such patients. This could facilitate patient-centered care at more accessible locations and overcome the current fragmentation of services.

The increasing trend of diabetes prevalence among Qatar's population, lack of awareness of knowledge and attitudes toward risk factors responsible for developing and managing diabetes, increasing prevalence of DR, and inadequate coverage of screening for DR in Qatar are matters of concern. Focusing on the prevention of diabetes, population-wide screening to diagnose diabetes early, effective mass campaigns on increasing awareness of diabetes, its prevention and management to avoid complications are major tasks at hand for Qatar.

Early detection and treatment of DR are key public health interventions that can greatly reduce the prevalence of vision loss in the diabetic population within the state of Qatar. Current DR screening programs typically employ ophthalmologists to do direct/indirect ophthalmoscopy or retinal photography. Opthalmoscopy relies on skilled readers for manual DR assessment which makes it highly labour-intensive, suffers from inconsistency across sites making it unreliable, unreproducible and cost ineffective measures in today's time. Is it time to consider digital retinal photography as a tool to increase early diagnosis of DR in patients suffering from diabetes?

CONCLUSION

In view of the growing diabetes epidemic, it is vital for policymakers and stakeholders to address the key health concerns for diabetes complications such as DR. Integrated care using digital retinal screening has the potential to facilitate timely consistent diagnosis and treatment for patients reducing significant burden for individuals and society. At present there is no definitive answer for developing countries where screening is more challenging due to low resources, lack of scale, and geographical isolation. Digital Retinal photography will have a reduction in inconsistencies and can be more accessible even as mobile units can be closer to communities, leading to early accurate, reproducible diagnosis and early interventions preventing and treating blindness at early stages in diabetic patients with retinopathy. In Qatar, advances in retinal imaging techniques can potentially transform the management of patients with diabetes, providing savings in health care costs and resources.

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REFERENCES

1. Cho NH, Shaw JE, Karuranga S, Huang Y, Da Rocha Fernandes JD, Ohlrogge AW, et al. IDF Diabetes Atlas: Global estimates of diabetes prevalence for 2017 and projections for 2045. Diabetes Res Clin Pract. 2018;138:271-81.
2. Vujosevic S, Aldington SJ, Silva P, Hernández C, Scanlon P, Peto T, et al. Screening for diabetic retinopathy: new perspectives and challenges. Lancet Diabetes Endocrinol. 2020;8(4):337-47.
3. Leasher JL, Bourne RR, Flaxman SR, Jonas JB, Keeffe J, Naidoo K, et al. Global estimates on the number of people blind or visually impaired by diabetic retinopathy: a meta-analysis from 1990 to 2010. Diabetes Care. 2016;39(9):1643-9.
4. Flaxman SR, Bourne RR, Resnikoff S, Ackland P, Braithwaite T, Cicinelli MV, et al. Global causes of blindness and distance vision impairment 1990–2020: a systematic review and meta-analysis. Lancet Global Heal. 2017;5(12):e1221-34.
5. Global Burden of Disease 2019 Blindness and Vision Impairment Collaborators, Vision Loss Expert Group of the Global Burden of Disease Study. Causes of blindness and vision impairment in 2020 and trends over 30 years, and prevalence of avoidable blindness in relation to VISION 2020: the Right to Sight: an analysis for the Global Burden of Disease Study. Lancet Glob Heal. 2021;9(2):e144ee160.
6. Sivaprasad S, Gupta B, Crosby-Nwaobi R, Evans J. Prevalence of diabetic retinopathy in various ethnic groups: a worldwide perspective. Survey Ophthalmol. 2012;57(4):347-70.
7. Wong TY, Mwamburi M, Klein R. Rates of progression in diabetic retinopathy during different time periods: a systematic review and meta-analysis. Diabetes Care. 2009;32:2307-13.
8. Teo ZL, Tham YC, Yu M, Chee ML, Rim TH, Cheung N, et al. Global prevalence of diabetic retinopathy and projection of burden through 2045: systematic review and meta-analysis. Ophthalmology. 2021;128(11):1580-91.
9. Diabetic Retinopathy Study Research Group, 1981. Photocoagulation treatment of proliferative diabetic retinopathy: clinical application of Diabetic Retinopathy Study (DRS) findings, DRS Report Number 8. Ophthalmology. 1981;88(7):583-600.
10. Ferris FL. How effective are treatments for diabetic retinopathy? JAMA. 1993;269(10):1290-91.
11. ICO Guidelines for Diabetic Eye Care. Available at: http://www.icoph.org/dynamic/attachments/resources/icoguidelinesfordiabeticeyecare.pdf. Accessed on 15 June, 2023.
12. Andermann A, Blancquaert I, Beauchamp S, Déry V. Revisiting Wilson and Jungner in the genomic age: a review of screening criteria over the past 40 years. Bull Worl Heal Organ. 2008;86(4):317-9.
13. Geneva: Switzerland, 2007. World Health Organization. Diabetic Retinoopathy; Disease Control and Prevention of Visual impairment in 'VISION 2020 Global Initiative for the Elimination of Avoidable Blindness: Action Plan 2006-2011'. 2007;34-6.
14. Harding SP, Broadbent DM, Neoh C, White MC, Vora J. Sensitivity and specificity of photography and direct ophthalmoscopy in screening for sight threatening eye disease: the Liverpool Diabetic Eye Study. BMJ. 1995;311(7013):1131-5.
15. Liew G, Mitchell P, Wang JJ, Wong TY. Fundoscopy: to dilate or not to dilate? BMJ. 2006;332:3.
16. Early Treatment Diabetic Retinopathy Study Research Group, 1991. Early Treatment Diabetic Retinopathy Study design and baseline patient characteristics: ETDRS report number 7. Ophthalmology. 1991;98(5):741-56.
17. Chakrabarti R, Harper CA, Keeffe JE. Diabetic retinopathy management guidelines. Expert Rev Ophthalmol. 2012;7(5):417-39.

18. British Diabetic Association: Retinal Photography Screening for Diabetic Eye Disease. London, British Diabetic Association. 1997.
19. Hutchinson A, McIntosh A, Peters J, O'keeffe C, Khunti K, Baker R et al. Effectiveness of screening and monitoring tests for diabetic retinopathy–a systematic review. Diabetic Med. 2000;17(7):495-506.
20. Liew G, Michaelides M, Bunce C. A comparison of the causes of blindness certifications in England and Wales in working age adults (16–64 years), 1999–2000 with 2009–2010. BMJ Open. 2014;4(2):e004015.
21. Jones S, Edwards RT. Diabetic retinopathy screening: a systematic review of the economic evidence. Diabetic Med. 2010;27(3):249-56.
22. World Health Organization, 2020. Diabetic retinopathy screening: a short guide: increase effectiveness, maximize benefits and minimize harm. Available at: https://apps.who.int/iris/bitstream/handle/10665/336660/9789289055321-eng.pdf. Accessed on 15 June 2023.
23. Silva PS, Cavallerano JD, Tolls D. Potential efficiency benefits of nonmydriatic ultrawide field retinal imaging in an ocular telehealth diabetic retinopathy program. Diabetes Care. 2014;37:50-5.
24. Olson JA, Strachan FM, Hipwell JH. A comparative evaluation of digital imaging, retinal photography and optometrist examination in screening for diabetic retinopathy. Diabetic Med. 2003;20:528-34.
25. Sharma M, Chakrabarty AS, Pavan R, Sharma R, Pratibha G. An integrated, mobile service for diabetic retinopathy in rural India. Community eye health / International Centre for Eye Health. 2011;24:17-8.
26. Nguyen HV, Tan GSW, Tapp RJ, Mital S, Ting DSW, Wong HT et al. Cost-effectiveness of a national telemedicine diabetic retinopathy screening program in Singapore. Ophthalmology. 2016;123(12):2571-80.
27. Khandekar R. Screening and public health strategies for diabetic retinopathy in the Eastern Mediterranean region. Middle East African J Ophthalmol. 2012;19(2):178.
28. Al Alawi E, Ahmed AA. Screening for diabetic retinopathy: the first telemedicine approach in a primary care setting in Bahrain. Middle East Afr J Ophthalmol. 2012;19(3):295.
29. Bener A, Zirie M, Janahi IM, Al-Hamaq AO, Musallam M, et al. Prevalence of diagnosed and undiagnosed diabetes mellitus and its risk factors in a population-based study of Qatar. Diabetes Res Clin Pract. 2009;84(1):99-106.
30. National health strategy 2018-2022. Available at: https://www.moph.gov.qa/english/strategies/National-Health-Strategy-2018-2022/ Pages/default.aspx.
31. Al-Thani, A.A., Farghaly, A., Akram, H., Khalifa, S., Vinodson, B., Loares, A. and Abou-Samra, A.B., 2019. Knowledge and perception of diabetes and available services among diabetic patients in the state of Qatar. Central Asian journal of global health, 8(1).
32. Al-Mutawaa KA, Farghaly A., Nasir R, Loares AM, Skaroni I, Al-Thani M, et al. Level of knowledge, attitude and practice towards diabetes among nationals and long-term residents of Qatar: a cross-sectional study. BMJ open. 2022;12(2): p.e052607.
33. www.hamad.qa. (n.d.). Diabetic Retinopathy among Most Common Eye Diseases Treated at HMC. Available at: https://www.hamad.qa/EN/news/2018/November/Pages/Diabetic-Retinopathy-among-Most-Common-Eye-Diseases-Treated-at-HMC.aspx. Accessed on 15 June, 2023.
34. Elshafei M, Gamra H, Khandekar R, Hashimi MA, Pai A et al. Prevalence and determinants of diabetic retinopathy among persons≥ 40 years of age with diabetes in Qatar: a community-based survey. Eur J Ophthalmol. 2011;21(1):39-47.

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