Mitigating the Prevalence of Diabetic Retinopathy in the United States: Utilization of the Chronic Care Model as a Public Health Framework

Anthony Obiyom Kamalu[1]*, Austin Ebhodaghe Ekeoba[2], Emeka Canice Uzor[2], Christian Chukwuka Duru[3], Obinna Princewill Anyatonwu[4], Ogemdi Emmanuel Adiele[5], Chibuike Reginald Amuzie[6], Chima Lawrence Odoemenam[3]

[1]Public Health Department, Louisiana State University Shreveport, Shreveport, USA
[2]College of Optometry, State University of New York, New York, USA
[3]Faculty of Medicine and Health Sciences, Department of Optometry, Imo State University, Owerri, Nigeria
[4]Epidemiology and Global Health Unit, Department of Public Health and Clinical Medicine, Umea University, Umea, Sweden
[5]College of Medicine, Georgetown University, Washington DC, USA
[6]Public Health Department, School of Allied Health Professionals, Louisiana State University Health Shreveport, Shreveport, USA
Email: *Anthony.kamalu@lsus.edu

Abstract

As the prevalence of diabetic retinopathy continues to be on the rise, the Chronic Care Model (CCM) offers a transformative, patient-focused approach for efficient diabetic retinopathy care, emphasizing the need for urgent and innovative strategies in the United States. The model integrates community resources, healthcare organizations, self-management support, delivery system design, decision support, and clinical information systems. Addressing challenges and solutions, the model emphasizes proactive and preventive measures, collaborative multidisciplinary care, technological integration, and overcoming resistance to change. This paper proposes the utilization of the Chronic Care Model (CCM) as a possible public health framework for comprehensive management of diabetic retinopathy in the United States. Implementing the CCM offers a comprehensive approach to diabetic retinopathy care, addressing both individual and systemic factors, essential for improving public health outcomes.

Keywords

Chronic Care Model, Diabetes, Diabetic Retinopathy, Model Implementation, Vision Care

1. Introduction

Diabetes is a chronic metabolic disease that is marked by increased blood sugar levels, which, over time, causes damage to the kidneys, heart, eyes, nerves, and blood vessels, and results in reduced quality of life and/or death [1]. The elevated blood sugar levels characteristic of the disease is caused specifically by defects in the secretion of insulin, the action of insulin in the body, or both [2]. Diabetes is a leading cause of morbidity and mortality worldwide, with about 422 million people recorded to be living with the disease and 1.5 million deaths directly connected to the disease in 2014 [1]. In the United States, specifically, 38.4 million people, representing 11.6% of the population, had the disease in 2021 while 399,401 people died from it in the same year, with 1.2 million new diagnoses made each year [3]. Financially, diabetes is a burdensome disease, with direct medical costs taking up $306.6 billion from the American populace while indirect costs accounted for another $106.3 billion in 2022 [3]. In 2021, the proportion of people in the United States with diabetes who had non-vision threatening diabetic retinopathy were 21.37% for all races, while 5.06% of the same population were found to have the vision threatening variant of the complication (see Table 1). One of the consequences and the most common complication of the disease, especially when not properly managed, is diabetic retinopathy [4]. Diabetic retinopathy may lead to vision loss when not properly managed. It arises when blood glucose is poorly controlled over an extended period, thus causing damage to the small blood vessels in the retina, leading to various ocular complications including neovascularization, hemorrhage, cotton-wool spots, hard exudates etc. (see Figure 1). This paper discusses diabetic retinopathy and the application of the Chronic Care Model (CCM) as a public health framework in mitigating the prevalence of diabetic retinopathy in the United States.
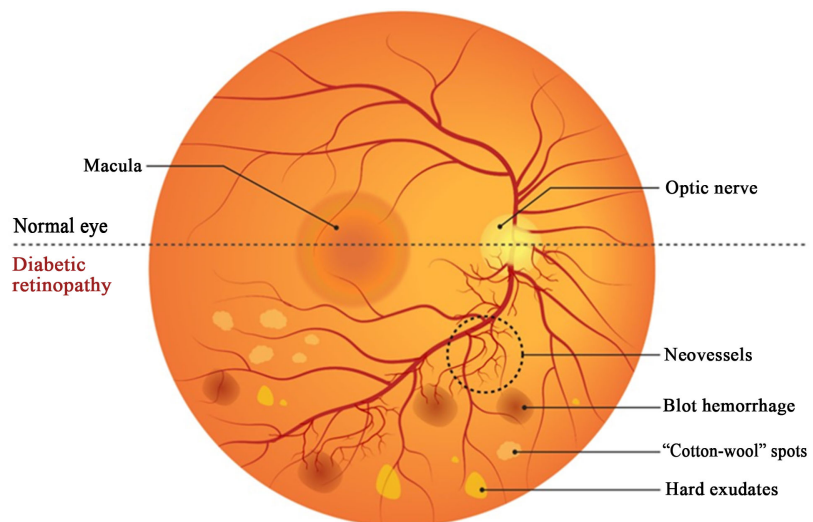
Figure 1. Diabetic retinopathy hallmarks (Illustration created with BioRender.com).

Table 1. The proportion of people in the United States with diabetes who also have diabetic retinopathy in 2021, by Stage of Disease and Race/Ethnicity (Adapted from Statista.com) [5].

Race group	Non-Vision-Threatening Diabetic Retinopathy	Vision-Threatening Diabetic Retinopathy
All races	21.37%	5.06%
Black, non-Hispanic	25.24%	8.57%
Hispanic, any race	21.14%	6.9%
Other	16.38%	4.75%
White, non-Hispanic	21.28%	3.61%

2. Diabetic Retinopathy: Prevalence and Burden

Described by the American Diabetes Association as a highly specific neurovascular complication [6], diabetic retinopathy is a secondary complication of diabetes that results in retinal damage in the form of retinal aneurysms, oedema, and hemorrhage, and can lead to loss of vision [7]. The major risk factors of the disease include duration of diabetes, high HbA1c levels occasioned by inadequate glycemic control, and comorbid hypertension [4]. Diabetic retinopathy is the commonest complication of diabetes and is the leading cause of avoidable blindness among working-age people in developed countries, resulting in reduced vision-specific and general quality of life, loss of productivity, precipitation of mental health problems, and a significant increase in direct and indirect medical costs [4] [8] [9] [10] [11], all of which negatively impact the socio-economic, mental, and physical wellbeing of members of the community. In 2020, the number of people with diabetic retinopathy globally was 103.12 (prevalence of 6.17%), with this number projected to increase to 160.5 million by 2045 [12], and 2.6% of blindness globally attributed to elevated blood sugar levels [6] [13]. In the United States, 9.6 million people were reported to be living with the disease in 2021 and 1.84 million of that number specifically had vision-threatening diabetic retinopathy [14]. With the number of people with diabetes projected to rise to 643 million by 2030 and 783 million by 2045 [15], the prevalence and burden of diabetic retinopathy is expected to follow this trend and thus presents a significant future problem that requires urgent and concerted effort to remedy.

3. Chronic Care Model (CCM)

There are several care models utilized in addressing public health issues in the population, and one of them is the Chronic Care Model (CCM). CCM identifies abd integrates the essential components within a healthcare system that promote the delivery of excellent care for chronic diseases (see Figure 2). Developed in the 1990s, CCM is an evidence-based approach to the re-organization of primary care and incorporates and implements essential components that allow primary care to proactively respond to patients with chronic diseases [17]. There are components to the CCM that have made it a successful model in the management
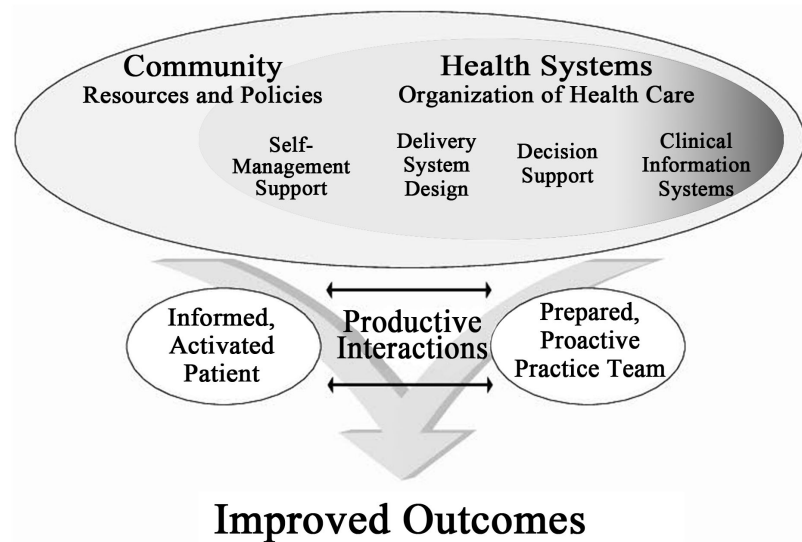
Figure 2. The chronic care model, adapted from Wagner, E. H. (1998) [16].

of chronic diseases within the primary healthcare system. In the original form, these components include facilitating patient self-management, implementing patient-centered and evidence-based care, mobilizing, and utilizing community resources, effectively utilizing demographic/patient data, promoting qualitative care, delivery coordinated care, health promotion, and cultural competence [18]. Implementation of the model has resulted in success and significantly better prognosis for chronic diseases including diabetes [19] [20] [21] [22], although there are limitations to its successful implementation, especially in multimorbidity [17]. However, success of the implementation of the model is dependent on factors at the levels of the team, healthcare provider, systems, and organizations, as well as contextual and human factors [18] [23] [24]. Below are the six components of the model which can be applied to mitigate the prevalence of diabetic retinopathy.

3.1. Community Resources

The community resources component of the CCM involves the mobilization of community resources to meet the needs of patients through community programs and partnerships between health organizations and community organizations [25]. Engaging community resources in diabetic retinopathy prevention is essential for developing a holistic and community-centered approach. By leveraging local knowledge, support networks, and outreach programs, healthcare professionals can enhance preventive measures, increase accessibility to care, and promote overall community well-being. The goal of this component is to create initiatives that are advantageous to patients and enhance healthcare policies [26].

Partnering with local organizations empowers eyecare providers to conduct targeted outreach and education campaigns on diabetic retinopathy, thus enhancing community awareness by facilitating widespread dissemination of pre-

ventive information and the creation of accessible screening programs [27]. Through partnerships, community organizations, support groups, and educational institutions synergize efforts for a comprehensive, culturally sensitive, and accessible strategy in diabetic retinopathy prevention. This collaboration enhances early detection and preventive care for at-risk individuals by tailoring interventions to specific cultural contexts during community engagement, promoting increased acceptance and participation in preventive measures. Support for local programs addressing nutrition, physical activity, and diabetes management builds crucial support networks for those with diabetes. Community engagement endeavors work towards mitigating healthcare disparities and promoting universal access to preventive measures, as well as mobilizing community resources, empowering stakeholders to advocate for improved policies, increasing funding, and implementing sustainable strategies against diabetic retinopathy [28]. Additionally, community engagement may aid in local data collection, supporting accurate surveillance and targeted interventions to combat diabetes and its ocular and general complications.

3.2. Healthcare Organization

Integrating eye care services into the existing healthcare systems in the United States is paramount for the effective prevention of diabetic retinopathy and aligns with a patient-oriented, coordinated, and proactive approach [29]. This integration will address the unique needs of individuals with diabetes, promoting early detection, timely intervention, and a comprehensive strategy to safeguard ocular health within the broader framework of diabetes care. This imperative is underscored by several key considerations within the U.S. healthcare landscape.

Primary care integration allows for regular screenings within routine checkups, enhancing early detection and timely intervention for diabetic retinopathy [30]. Telehealth integration extends accessibility, particularly for remote or underserved areas, playing a pivotal role in expanding reach and facilitating consultations [31]. Streamlined coordination among healthcare professionals ensures a comprehensive approach to managing diabetes and its ocular complications [32]. Collaborative efforts among multidisciplinary teams optimize resource utilization, contributing to more efficient patient care. Aligning with public health initiatives, integrated eye care services implement targeted awareness campaigns, fostering a proactive culture of eye health management among individuals with diabetes. Robust health information exchange mechanisms, standardized protocols, collaboration with insurance systems, workforce development, and research integration collectively contribute to a comprehensive strategy that safeguards ocular health within the broader framework of diabetes care.

Establishing specialized clinics for diabetic retinopathy screening within U.S. healthcare organizations offers a tailored and comprehensive approach to prevention and management as it holds significant potential for enhancing the pre-

vention, diagnosis, and management of diabetic retinopathy [33]. These clinics will not only enhance the delivery of specialized care but also contribute to advancements in research, patient education, and overall healthcare efficiency. By streamlining patient pathways, they facilitate efficient access to tailored eye care services, reducing delays in diagnosis and treatment.

3.3. Self-Management Support

This component of the model emphasizes individual care and encourages patients' proactive engagement in the management of their visual health [34]. If applied correctly, it may serve as a foundational framework for empowering individuals with diabetes in the U.S. to actively manage their eye health. It offers a holistic approach, emphasizing collaboration and personalized strategies to empower individuals in effectively managing both diabetes and eye health.

The component encourages proactive health management through comprehensive education, individualized care plans, collaborative goal setting, and skill building. Establishing support networks, cultural competence, and collaboration with healthcare providers enhances patient empowerment and fosters a sense of ownership [34]. Continuous monitoring, feedback systems, and technology integration, such as mobile apps and telehealth platforms, enable active participation in self-management and eye health. Promoting healthy lifestyles, including nutrition and exercise, contributes to overall well-being and prevents complications like diabetic retinopathy.

Delivering education, resources, and tools for self-monitoring remains crucial for individuals with diabetes in the U.S., as it raises awareness, enhances self-management, and actively engages them in preventing diabetic retinopathy [35]. Key components include accessible educational initiatives covering diabetic retinopathy and the importance of regular eye screenings, whichpromote proactive monitoring. Providing user-friendly blood glucose monitoring tools enables active management of glucose levels, a critical factor in prevention. Offering nutritional guidance, promoting physical activity, and ensuring medication adherence contribute to overall diabetes control, thereby reducing the risk of complications [36]. Emphasizing regular comprehensive health check-ups, including eye examinations, reinforces holistic health monitoring and ensures active engagement, timely interventions, and a proactive stance toward preserving ocular health among individuals with diabetes.

3.4. Delivery System Design

In the prevention and management of diabetic retinopathy, emphasis on delivery system design is pivotal. Improving the well-being of individuals with chronic ailments such as diabetes necessitates a shift from a reactive, fragmented healthcare model, which primarily addresses acute events, to a proactive, holistic approach that prioritizes continuous care, integrates various services, and centers on individuals and families, aiming to promote and sustain health [25]. By

aligning the delivery system with the principles of the Chronic Care Model, healthcare providers can create a more patient-oriented approach to diabetic retinopathy care. This entails restructuring healthcare delivery for a seamless, patient-centric experience. Key components for enhancing diabetic retinopathy eye care services via a patient-centric approach involves collaborative team care comprising optometrists, ophthalmologists, endocrinologists, and diabetes educators to ensure comprehensive support [37]. Other essential aspects include proactive patient involvement, coordinated care, decision aid tools, health tech integration, population health oversight, and patient empowerment strategies.

Systems must be implemented to facilitate smooth transitions between healthcare providers and settings, ensuring consistent, well-coordinated care, particularly vital in managing complex conditions like diabetic retinopathy. Integration of evidence-based guidelines and decision-support tools aids healthcare providers in informed decision-making about diabetic retinopathy diagnosis, treatment, and management. Leveraging electronic health records and technologies enhances communication, secures sharing of patient information, and tracks outcomes, ensuring continuity and timely interventions [38]. Strategies for population health management, including proactive outreach, risk stratification, and tailored interventions, are essential for improved overall health outcomes. Actively empowering patients in their eye care entails involving them in shared decision-making, goal setting, and continuous support to enhance self-efficacy in managing diabetic retinopathy.

3.5. Clinical Decision Support

Utilizing the clinical decision support component of the Chronic Care Model (CCM) in addressing diabetic retinopathy involves advocating for vision care aligned with both scientific evidence and patient preferences. Evidence-based decision-making is paramount for effective care [39], and eyecare professionals can utilize various tools and guidelines to inform their decisions daily in clinical practice. These include evidence-based clinical practice guidelines provided by organizations such as the American Diabetes Association, the World Health Organization, American Academy of Ophthalmology, the American Optometric Association etc. Additionally, diagnostic tools like fundus photography, optical coherence tomography, and fluorescein angiography aid in accurate assessment.

Training programs play a crucial role in equipping clinicians with the necessary skills for diabetic retinopathy management [40]. Continual educational outreach to eyecare professionals reinforces utilization of these standards. It helps them share evidence-based guidelines and information with patients to encourage their participation, use proven provider education methods, and integrate specialist expertise in primary care. These programs should cover the latest advancements in diagnostic technologies, treatment modalities, and patient care strategies. Continuing education courses, workshops, and hands-on

training sessions ensure that healthcare professionals stay updated on best practices, fostering continuous improvement in diabetic retinopathy management. Increasing patients' understanding involves engaging in discussions and making clinical decisions collaboratively with patients. Implementing practice changes requires clinical guidelines to integrate system alerts, reminders, and feedback [41]-[47].

3.6. Clinical Information Systems

This component of the model involves the organization of patient data to facilitate efficient and effective vision care. It streamlines communication, promotes collaboration among healthcare providers, enhances decision-making, and empowers patients in the comprehensive management of diabetic retinopathy. Clinical information systems utilize technology to provide clinicians with a comprehensive roster (registry) of diabetes patients. Subsequently, this registry provides the requisite data to oversee patient health and visual status, thereby mitigating complications.

The integration of patient data into electronic health records (EHRs) possesses significant potential for optimizing the management of diabetic retinopathy. It provides timely notifications for both healthcare providers and patients, identifies distinct subpopulations for proactive healthcare, assists in developing personalized patient care plans, facilitates the exchange of information between patients and providers for collaborative care, and supervises the performance of practice teams and care systems. It is a process that involves incorporating eye care data, such as diagnostic results, treatment plans, and follow-up appointments, into EHRs, thereby facilitating the creation of comprehensive and centralized patient records. Integration improves coordination among healthcare providers for comprehensive diabetic retinopathy management. Effective communication between specialists is facilitated through Electronic Health Records (EHRs) [48], ensuring timely access to critical eye care information. This integration supports evidence-based guidelines, promoting standardized care. Patients benefit from enhanced continuity, reduced redundancy in sharing medical history, and active engagement in their diabetic retinopathy management, promoting shared decision-making and treatment adherence.

4. Model Implementation: Potential Challenges and Solutions

Implementation of the Chronic Care Model (CCM) in the manner discussed above promises a mitigation of the prevalence of diabetic retinopathy. However, there are certain factors that may impede its successful implementation. Asides the general barriers to the successful implementation of this model as contained in the literature [16] [21] [22] hinderances specific to diabetic retinopathy may arise from the unwillingness of community organisations to participate in collaborations, late diagnosis of diabetic retinopathy, and people with diabetes not following up on prescribed self-management regimen. The unwillingness of the

community to participate in collaborations may be informed by the fact that diabetic retinopathy is not life-threatening. As such, communities may be unwilling to prioritise collaborations for diabetic retinopathy in the face of "more serious" community health needs like mental health, substance abuse, and reproductive health. This unwillingness or low priority will result in little or no collaborations and thus negatively impact the success of the model. As remedy, efforts should be made in sensitising such communities on the socio-economic consequences of diabetic retinopathy and impress on them how participating in such collaborations will benefit members of the community in different ways.

Another hinderance to the successful implementation of the model for diabetic retinopathy care may arise from the inability of diabetic patients to follow through with prescribed self-management regimen to ensure the prevention of the disease or mitigate the occurrence of diabetic retinopathy. This self-management regimen may be in the form of self-control of blood glucose, medication, and/or lifestyle and behavioural changes. This inability to follow through with self-management regimen may be further encouraged by the fact that diabetic retinopathy does not tend to present symptoms at its early stages [49] [50], and as such patients may see no need to keep up with self-management. As remedy, efforts and systems should be instituted to ensure follow up on patients undergoing self-management. This monitoring will ensure that the self-management component of the model achieves desired goals and thus guarantees the overall effectiveness of the model.

Furthermore, another barrier to the model that is specific to diabetic retinopathy may emanate from the late diagnosis of the disease. As mentioned earlier, diabetic retinopathy does not tend to show symptoms in its initial stages [49] [50], and this may result in late diagnosis of the disease, and subsequently, late commencement of interventions. The late diagnosis may be due to late patient presentation for screening or examination. This means that the aim of applying this model, which is to mitigate the prevalence of diabetic retinopathy, may not be achieved even when components of the model like integrating eye care services into the existing healthcare systems have been successfully put in place.

5. Conclusion

The Chronic Care Model (CCM) emerges as a transformative framework for reshaping diabetic retinopathy care in the U.S. This comprehensive approach addresses the multifaceted challenges posed by diabetic retinopathy, offering a synergistic strategy through community engagement, healthcare organization integration, self-management support, delivery system design, decision support, and clinical information systems. Proactive and preventive measures, multidisciplinary collaboration, and technological integration under the CCM present a promising avenue to reduce complications, prevent vision loss, and enhance the management of diabetic retinopathy. As the prevalence of diabetes and its associated complications continues to escalate, the CCM stands as a beacon for a pa-

tient-centered, efficient, and proactive future in diabetic retinopathy care, emphasizing the urgency of transformative approaches to address this significant public health concern in the U.S.

Author Contributions Statement

AOK, AEE and ECU contributed to the paper structure, outline, and the initial manuscript. CCD, CRA and OPA verified the data and all sources of literature. AOK, AEE, ECU, CCD, OPA, OEA and CLO reviewed the final manuscript critically. All authors significantly contributed to the intellectual content of the manuscript.

Acknowledgements

Our heartfelt gratitude extends to all who played a role in making this paper a success.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] World Health Organization (2023) Diabetes.
https://www.who.int/health-topics/diabetes#tab=tab_1

[2] American Diabetes Association (2010) Diagnosis and Classification of Diabetes Mellitus. *Diabetes Care*, **33**, S62-S69. https://dx.doi.org/10.2337/dc10-S062

[3] American Diabetes Association (2023) Statistics about Diabetes.
https://diabetes.org/about-diabetes/statistics/about-diabetes

[4] Simó-Servat, O., Hernández, C. and Simó, R. (2019) Diabetic Retinopathy in the Context of Patients with Diabetes. *Ophthalmic Research*, **62**, 211-217.
https://dx.doi.org/10.1159/000499541.

[5] Elflein, J. (2023) Prevalence of Diabetic Retinopathy by Stage U.S. 2021.
https://www.statista.com/statistics/1417726/prevalence-of-diabetic-retinopathy-in-us-by-stage/

[6] Solomon, S.D., Chew, E., Duh, E.J., *et al*. (2017) Diabetic Retinopathy: A Position Statement by the American Diabetes Association. *Diabetes Care*, **40**, 412-418.
https://dx.doi.org/10.2337/dc16-264

[7] Ansari, P., Tabasumma, N., Snigdha, N.N., *et al*. (2022) Diabetic Retinopathy: An Overview on Mechanisms, Pathology and Pharmacology. *Diabetology*, **3**, 159-175.
https://dx.doi.org/10.3390/diabetology3010011

[8] Alcubierre, N., Rubinat, E., Traveset, A., *et al*. (2014) A Prospective Cross-Sectional Study on Quality of Life and Treatment Satisfaction in Type 2 Diabetic Patients with Retinopathy without Other Major Diabetic Complications. *Health and Quality of Life Outcomes*, **12**, Article No. 131.
https://dx.doi.org/10.1186/s12955-014-0131-2

[9] Yau, J.W.J., Rogers, S.L., Kawasaki, R., *et al*. (2012) Global Prevalence and Major Risk Factors of Diabetic Retinopathy. *Diabetes Care*, **35**, 556-564.
https://dx.doi.org/10.2337/dc11-1909

[10] Wong, T.Y., Cheung, C.M., Larsen, M., Sherma, S. and Simó, R. (2016) Diabetic Re-

tinopathy. *Nature Reviews: Disease Primers*, **2**, Article No. 16012. https://dx.doi.org/10.1038/nrdp.2016.12

[11] Willis, J.R., Doan, Q.V., Gleeson, M., *et al*. (2017). Vision-Related Functional Burden of Diabetic Retinopathy across Severity Levels in the United States. *JAMA Ophthalmology*, **135**, 926-932. https://dx.doi.org/10.1001/jamaophthalmol.2017.2553

[12] Teo, Z.L., Tham, Y.C., Yu, M., Chee, M.L., Rim, T.H., Cheung, N., Bikbov, M.M., Wang, Y.X., Tang, Y., Lu, Y., Wong, Y., Ting, D.S.W., Tan, G.S.W., Jonas, J.B., Sabanayagam, C. Wong, T.Y. and Cheng, C.Y. (2021) Global Prevalence of Diabetic Retinopathy and Projection of Burden through 2045: Systematic Review and Meta-Analysis. *Ophthalmology*, **128**, 1580-1591. https://dx.doi.org/10.1016/j.ophtha.2021.04.027

[13] Song, P., Yu, J., Chan, K.Y., Theodoratou, E. and Rudan, I. (2018) Prevalence, Risk Factors and Burden of Diabetic Retinopathy in China: A Systematic Review and Meta-Analysis. *Journal of Global Health*, **8**, Article ID: 010803. https://dx.doi.org/10.7189/jogh.08010803

[14] Lundeen, E., Burke-Conte, Z. and Rein, D.B. (2023) Prevalence of Diabetic Retinopathy in the US in 2021. *JAMA Ophthalmology*, **141**, 747-754. https://dx.doi.org/10.1001/jamaophthalmol.2023.2289

[15] International Diabetes Federation (2021) IDF Diabetes Atlas. 10th Edition, International Diabetes Federation, Brussels. https://diabetesatlas.org/atlas/tenth-edition/

[16] Wagner, E.H. (1998) Chronic Disease Management: What Will It Take to Improve Care for Chronic Illness? *Effective Clinical Practice*, **1**, 2-4.

[17] Boehmer, K.R., Dabrh, A.M., Gionfriddo, M.R., Erwin, P. and Montori, V.M. (2018) Does the Chronic Care Model Meet the Emerging Needs of People Living with Multimorbidity? A Systematic Review and Thematic Synthesis. *PLOS ONE*, **13**, e0190852. https://dx.doi.org/10.1371/journal.pone.0190852

[18] Davey, C., Bleasel, J., Liu, H., Tchan, M., Ponniah, S. and Brown, A. (2015) Factors Influencing the Implementation of the Chronic Care Models: A Systematic Literature Review. *BMC Family Practice*, **16**, Article No. 102. https://dx.doi.org/10.1186/s12875-015-0319-5

[19] Moullec, G., Gour-Provencal, G., Bacon, S.L., Campbell, T.S. and Lavoie, K.L. (2012) Efficacy of Interventions to Improve Adherence to Inhaled Corticosteroids in Adult Asthmatics: Impact of Using Components of the Chronic Care Model. *Respiratory Medicine*, **106**, 1211-1225. https://dx.doi.org/10.1016/j.rmed.2012.06.001

[20] Goh, L.H., Siah, C.J.R., Tam, W.W.S., Tai, E.S. and Young, D.Y.L. (2022) Effectiveness of the Chronic Care Model for Adults with Type 2 Diabetes in Primary Care: A Systematic Review and Meta-Analysis. *Systematic Reviews*, **11**, Article No. 273. https://dx.doi.org/10.1186/s13643-022-02117-w

[21] Baptista, D.R., Wiens, A., Pontarolo, R., Regis, L., Reis, W.C.T. and Correr, C.J. (2016) The Chronic Care Model for Type 2 Diabetes: A Systematic Review. *Diabetology and Metabolic Syndrome*, **8**, Article No. 7. https://dx.doi.org/10.1186/s13098-015-0119-z

[22] Robusto, F., Bisceglia, L., Petrarolo, F., *et al*.(2018) The Effects of the Introduction of a Chronic Care Model-Based Program on Utilization of Healthcare Resources: the Results of the Puglia Care Program. *BMC Health Services Research*, **18**, Article No. 377. https://dx.doi.org/10.1186/s12913-018-3075-0

[23] Holm, A.L. and Severinsson, E. (2012) Chronic Care Model for the Management of

Depression: Synthesis of Barriers to, and Facilitators of, Success. *International Journal of Mental Health Nursing*, **21**, 513-523. https://dx.doi.org/10.1111/j.1447-0349.2012.00827.x

[24] Kadu, M. and Stolee, P. (2015) Facilitators and Barriers of Implementing the Chronic Care Model in Primary Care: A Systematic Review. *BMC Family Practice*, **16**, Article No. 12. https://dx.doi.org/10.1186/s12875-014-0219-0.

[25] Bodenheimer, T., Wagner, E.H., and Grumbach, K. (2002) Improving Primary Care for Patients with Chronic Illness: The Chronic Care Model, Part 2. *JAMA*, **288**, 1909-1914. https://doi.org/10.1001/jama.288.15.1909

[26] Simpson, K., Nham, W., Thariath, J., Schafer, H., Greenwood-Eriksen, M., Fetters, M.D., Serlin, D., Peterson, T. and Abir, M. (2022) How Health Systems Facilitate Patient-Centered Care and Care Coordination: A Case Series Analysis to Identify Best Practices. *BMC Health Services Research*, **22**, Article No. 1448.

[27] National Academies of Sciences, Engineering, and Medicine; Health and Medicine Division; Board on Population Health and Public Health Practice; Committee on Public Health Approaches to Reduce Vision Impairment and Promote Eye Health (2016) The Role of Public Health and Partnerships to Promote Eye and Vision Health in Communities. In: Welp, A., Woodbury, R.B., McCoy, M.A. and Teutsch, S.M., Eds., *Making Eye Health a Population Health Imperative: Vision for Tomorrow*, National Academies Press (US), Washington DC, 5. https://www.ncbi.nlm.nih.gov/books/NBK402363/

[28] Yuan, M., Lin, H., Wu, H., Tu, J. and Lü, Y (2021) Community Engagement in Public Health: A Bibliometric Mapping of Global Research. *Archive of Public Health*, **79**, Article No. 6. https://dx.doi.org/10.1186/s13690-021-00525-3

[29] Kocur, I., Krug, E., Mariotti, S.P. and McCoy, M. (2018) Benefits of Integrating Eye Care into Health Systems. *Bulletin of the World Health Organization*, **96**, 666-666A. https://DX.doi.org/10.2471/BLT.18.221887

[30] Wandy, T., Rayaz, S., Brager, J.A.L., Kiritsy, M., Offermann, E. and Durand, D. (2022) Colocating Teleophthalmology within Primary Care Settings to Improve Access to Diabetic Retinopathy Screening: Retrospective Descriptive Evaluation. *JMIR Formative Research*, **6**, e17838. https://dx.doi.org/10.2196/17838

[31] Gajarawala, S.N. and Pelkowski, J.N. (2021) Telehealth Benefits and Barriers. *Journal for Nurse Practitioners*, **17**, 218-221. https://dx.doi.org/10.1016/j.nurpra.2020.09.013

[32] Levengood, T.W., Peng, Y., Xiong, K.Z., *et al.* (2019) Team-Based Care to Improve Diabetes Management: A Community Guide Meta-Analysis. *American Journal of Preventive Medicine*, **57**, e17-e26. https://dx.doi.org/10.1016/j.amepre.2019.02.005

[33] Abou Taha, A., Dinesen, S., Vergmann, A.S. and Grauslund, J. (2024) Present and Future Screening Programs for Diabetic Retinopathy: A Narrative Review. *International Journal of Retina and Vitreous*, **10**, Article No. 14. https://dx.doi.org/10.1186/s40942-024-00534-8

[34] Institute of Medicine (US) Committee on the Crossing the Quality Chasm: Next Steps toward a New Health Care System (2004) Chapter 5. Patient Self-Management Support. In: Adams, K., Greiner, A.C. and Corrigan, J.M., Eds., *The 1st Annual Crossing the Quality Chasm Summit: A Focus on Communities*, National Academies Press (US), Washington DC. https://www.ncbi.nlm.nih.gov/books/NBK215507/

[35] Gómez-Velasco, D.V., Almeda-Valdes, P., Martagón, A.J., Galán-Ramírez, G.A. and Aguilar-Salinas, C.A. (2019) Empowerment of Patients with Type 2 Diabetes: Current Perspectives. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy*,

12, 1311-1321. https://dx.doi.org/10.2147/DMSO.S174910

[36] Sugandh, F., Chandio, M., Raveena, F., *et al*.(2023) Advances in the Management of Diabetes Mellitus: A Focus on Personalized Medicine. *Cureus*, **15**, e43697. https://dx.doi.org/10.7759/cureus.43697

[37] Mathur, R., de Korne, D., Wong, T.Y., *et al*. (2019) Shared Care for Patients with Diabetes at Risk of Retinopathy: A Feasibility Trial. *International Journal of Integrated Care*, **19**, Article No. 18. https://dx.doi.org/10.5334/ijic.4208

[38] Quinn, M., Forman, J., Harrod, M., *et al*. (2019) Electronic Health Records, Communication, and Data Sharing: Challenges and Opportunities for Improving the Diagnostic Process. *Diagnosis*, **6**, 241-248. https://dx.doi.org/10.1515/dx-2018-0036

[39] Shafaghat, T., Bastani, P., Nasab, M.H.I., *et al*. (2022) A Framework of Evidence-Based Decision-Making in Health System Management: A Best-Fit Framework Synthesis. *Archives of Public Health*, **80**, Article No. 96. https://dx.doi.org/10.1186/s13690-022-00843-0

[40] Team, H.E. (2023) The Role of Training and Development in Accelerating Healthcare Career Growth. Soft Skills for Healthcare. https://esoftskills.com/healthcare/the-role-of-training-and-development-in-accelerating-healthcare-careergrowth/#:~:text=Effective%20training%20and%20development%20programs,that%20positively%20impact%20patient%20outcomes

[41] Smith, S.A., Shah, N.D., Bryant, S.C., *et al*. (2008) Chronic Care Model and Shared Care in Diabetes: Randomized Trial of an Electronic Decision Support System. *Mayo Clinic Proceedings*, **83**, 747-757. https://dx.doi.org/10.4065/83.7.747

[42] Stroebel, R.J., Gloor, B., Freytag, S., *et al*. (2005) Adapting the Chronic Care Model to Treat Chronic Illness at a Free Medical Clinic. *Journal of Health Care for the Poor and Underserved*, **16**, 286-296. https://dx.doi.org/10.1353/hpu.2005.0041

[43] Siminerio, L.M., Piatt, G.A., Emerson, S., *et al*. (2006) Deploying the Chronic Care Model to Implement and Sustain Diabetes Self-Management Training Programs. *The Diabetes Educator*, **32**, 253-260. https://dx.doi.org/10.1177/0145721706287156

[44] Pereira, V.C., Silva, S.N., Carvalho, V.K.S., *et al*. (2022) Strategies for the Implementation of Clinical Practice Guidelines in Public Health: An Overview of Systematic Reviews. *Health Research Policy and Systems*, **20**, Article No. 13. https://doi.org/10.1186/s12961-022-00815-4

[45] MacLean, C.D., Littenberg, B., Gagnon, M., Reardon, M., Turner, P.D. and Jordan C. (2004) The Vermont Diabetes Information System (VDIS): Study Design and Subject Recruitment for a Cluster Randomized Trial of a Decision Support System in a Regional Sample of Primary Care Practices. *Clinical Trials*, **1**, 532-544. https://dx.doi.org/10.1191/1740774504cn051oa

[46] Lyles, C.R., Harris, L.T., Le, T., *et al*. (2011) Qualitative Evaluation of a Mobile Phone and Web-Based Collaborative Care Intervention for Patients with Type 2 Diabetes. *Diabetes Technology and Therapeutics*, **13**, 563-569. https://dx.doi.org/10.1089/dia.2010.0200

[47] Liebman, J., Heffernan, D. and Sarvela, P. (2007) Establishing Diabetes Self-Management in a Community Health Center Serving Low-Income Latinos. *The Diabetes Educator*, **33**, 132S-138S. https://dx.doi.org/10.1177/0145721707304075

[48] White, A. and Danis, M. (2013) Enhancing Patient-Centered Communication and Collaboration by Using the Electronic Health Record in the Examination Room. *JAMA*, **309**, 2327-2328. https://dx.doi.org/10.1001/jama.2013.6030

[49] Bajwa, A., Nosheen, N., Talpur, K.I. and Akram, S. (2023) A Prospective Study on

Diabetic Retinopathy Detection Based on Modify Convolutional Neural Network Using Fundus Images at Sind Institute of Ophthalmology & Visual Sciences. *Diagnostics*, **13**, Article No. 393. https://dx.doi.org/10.3390/diagnostics13030393

[50] Kumar, P.N.S., Deepak, R.U., Sathar, A., Sahasranamam, V. and Kumar, R.R. (2016) Automated Detection System for Diabetic Retinopathy Using Two Field Fundus Photography. *Procedia Computer Science*, **93**, 486-494.
https://dx.doi.org/10.1016/j.procs.2016.07.237