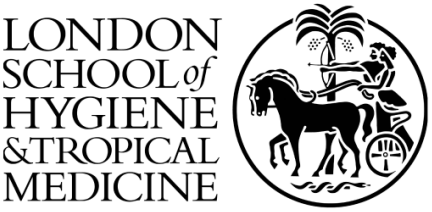


Assessment of public health services for diabetes mellitus and diabetic retinopathy during the COVID-19 pandemic in the State of Hidalgo, Mexico

Luis Alberto Martinez Juarez

Thesis submitted in accordance with the requirements for the degree of Doctor of Public Health

University of London

2022

Faculty of Infectious and Tropical Diseases

Department of Clinical Research

LONDON SCHOOL OF HYGIENE & TROPICAL MEDICINE

No funding received

If access to health care is considered a human right, who is considered human enough to have that right?

- Paul Farmer

Supervisors

Professor Allen Foster

Dr Daksha Patel

Advisors

Dr Covadonga Bascaran

Dr Hector Gallardo-Rincón

I, Luis Alberto Martinez Juarez confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Signed 

Date: November 1, 2021

Content

Initial Statement

On March 17, 2020, the DrPH seminar was held, where I presented a thesis proposal to the reviewers, with the following aim and objectives.

Aim: To assess the public health system for diabetic retinopathy services in the state of Hidalgo, and provide recommendations to strengthen the health system for the prevention of blindness and the delivery of comprehensive eye care services for persons with diabetes.

Objectives:

1. To estimate from the literature, the future magnitude of diabetes mellitus and diabetic retinopathy in Mexico and Hidalgo.
2. To assess the public health system for diabetic retinopathy care in Hidalgo using the "Tool for the assessment of diabetic retinopathy and diabetes management systems" (TADDS) of the World Health Organization.
3. To evaluate knowledge, attitude and practices (KAP) of patients with diabetes regarding the management of their disease and ocular complications.
4. To identify the major constraints to improve the services for diabetic retinopathy in Hidalgo.
5. To provide recommendations to the Minister of Health in Hidalgo to improve diabetic retinopathy services.

Due to the onset of the COVID-19 pandemic in Mexico, objective 3 which involved interviewing patients living with diabetes for their input in this thesis was not possible due to the lockdown in Mexico and the need for first-level health centres to prioritise their services on diagnosis and management of COVID-19 cases. Interviewing people living with diabetes was considered an unnecessary risk for patients and the researcher.

Given this situation, it was agreed with my supervisors and the DrPH assessors to replace the original objective with an assessment of the constraints that the COVID-19 pandemic was generating in providing services to people living with Diabetes and Diabetic Retinopathy.

In this modified proposal accepted by the reviewers, objective three was changed as follows:

3. To identify, in Hidalgo, the constraints on health providers in delivering services to persons living with diabetes and diabetic retinopathy resulting from the COVID-19 epidemic, and possible solutions.

Abstract

Background. Diabetes mellitus (DM) is a metabolic disease characterized by high levels of blood sugar, which affect different organs, including the eyes. Diabetic retinopathy (DR) is a complication of diabetes which can lead to vision loss.

Mexico has one of the highest prevalence of DM in the world. The management of DM and DR requires a health system prepared to prevent, diagnose, and offer timely treatment to the population that requires it. This remains important during the COVID-19 pandemic, which is a threat to the delivery of all health services.

Aims. To assess the public health system for DR services in the state of Hidalgo, identify the constraints resulting from COVID-19, and provide recommendations to maintain and strengthen the health system to prevent blindness and the delivery of comprehensive eye care services for persons living with diabetes.

Methods. This work follows a mixed-method descriptive study design. First, the current and future magnitude of DM and DR in Mexico and Hidalgo was estimated, in addition, available data on clinical service delivery for diabetes mellitus and diabetic retinopathy in Hidalgo in the period before the Covid-19 epidemic and during the epidemic were collated. Then, 13 key stakeholders from the public health sector in Mexico and the State of Hidalgo related to the development and implementation of policies and strategies for DM and DR were interviewed to assess the service provision for DM and DR through a tool for the assessment of diabetic retinopathy and diabetes management system (TADDS). They were also asked to identify the constraints on health providers resulting from the COVID-19 pandemic in delivering services to persons living with DM and DR. Finally, the major constraints to improve the eye care services were identified in order to provide recommendations and a policy brief for the Minister of Health in Hidalgo.

Results. Hidalgo with a population of approximately 3 million has an estimated 272,000 people living with diabetes of which approximately 90,000 are expected to have diabetic retinopathy and 21,000 require treatment for sight threatening retinopathy.

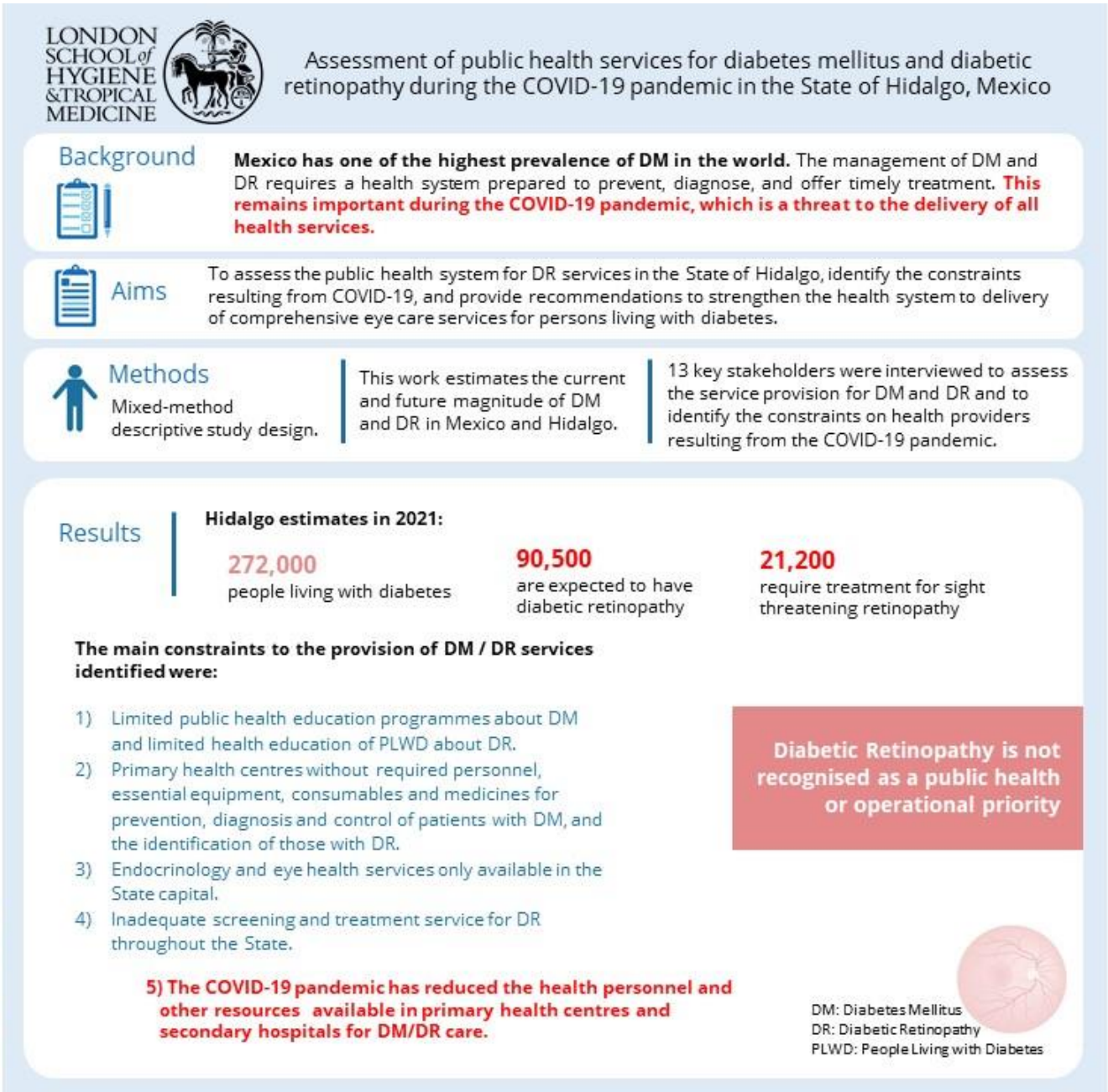
Responses to 41 questions from the TADDS instrument were analysed. The main constraints to the provision of DM / DR services were identified as a limited public health education programme about diabetes mellitus and limited health education of PLWD about DR. The primary health centres do not have the required personnel, equipment and essential consumables / medicines for prevention, diagnosis, and control of patients with DM, and the identification of those with DR. The specialist endocrinology and eye health services are only available in the State capital with no effective referral system between primary health centres and specialist eye health centre. There is an inadequate screening and treatment service for DR throughout the State.
Questions to identify the constraints on health providers resulting from the COVID-19 pandemic yielded 28 thematic nodes identifying delivery constraints due to the pandemic, and 40 thematic nodes providing possible solutions. The qualitative analysis of the interviews revealed that the COVID-19 pandemic has reduced the health personnel and other resources available in primary health centres and secondary hospitals for DM/DR care. Eight recommendations were identified for improving services to PLWD and seven for the provision of eye health services during and after the pandemic.

Conclusions. This study has shown that DM is a national health priority in Mexico, for which health promotion, preventive and therapeutic measures are inadequate. DR is not currently recognised as a

priority in available health policies, or by operational clinical guidelines across the continuum of DM/DR care.

In the state of Hidalgo those DM and DR services that are present have been severely reduced by the COVID epidemic. As requested by the Hidalgo health authority, a policy brief and specific recommendations are provided based on this study.

Visual Abstract



Acknowledgments

The DrPH programme has been a great personal, academic, and professional experience. I feel very privileged to have had the support, motivation, guidance and accompaniment of my supervisors Allen Foster and Daksha Patel. This experience would not have been possible without their support, especially during the difficult times experienced during the COVID-19 pandemic.

I would also like to thank all my teachers and fellow students in the programme who made this experience unique and from whom I had the privilege to learn. I am incredibly grateful to Cova, Julia, Majd, Liza, Javier, Gina and Daria, who made my stay in LSHTM and London so much easier all the time.

I am also really grateful to Professor Peter Piot, who, in addition to his friendship, I had the opportunity to learn from and publish our views on the pending NTD agenda during the COVID-19 pandemic.

I would also like to thank Dr Roberto Tapia-Conyer, Mtro. Ricardo Mujica and Dr Héctor Gallardo Rincón at the Carlos Slim Foundation for the privilege of working in this institution and for the support and mentoring they gave me to do the DrPH at LSTHM. Without a doubt, the COVID-19 pandemic has been a great personal and professional challenge. I feel very privileged to have been able to implement many of DrPH's learnings in the Temporary COVID-19 Hospital in Mexico City led by this foundation.

I would also like to extend my gratitude to the health authorities of the State of Hidalgo for their great interest and support in completing this thesis which evaluates the provision of health care of people living with diabetes and diabetic retinopathy in this State during the pandemic. In particular, to Dr Lourdes Carrillo for her friendship and mentoring on this issue. In addition, I would like to thank the Cinepolis Foundation and Lorena Guille for their interest in the subject of eye health in Mexico and for allowing me to carry out the OPA by evaluating the wonderful programme they have on the provision of cataract surgeries for the most economically vulnerable people in Mexico.

In addition, I would like to thank all the support and teachings of great friends and great professionals who undoubtedly made the experience of this DrPH easier and more complete, particularly Ana Cristina Sedas at Harvard University, Julieta Lomelín, Diego Alvarez, and Lorena Suarez at Carlos Slim Foundation, Miriam Orcutt and Michel Knipper at Lancet Migration, Raj Bophal at the University of Edinburgh, and Sir Andy Haines and Professor Vikram Patel at LSHTM.

Finally, and most importantly, I would like to thank my family, whom I love and admire very much, and who have supported me in all my aspirations and adventures. Without them, I could not be at this point in my life and professional experience.

Integrated Statement

Studying this DrPH programme has helped me improve my skills as a researcher, by focusing on learning about a particular topic, and also by learning new ideas about implementation sciences.

In addition to having taken advantage of the academic opportunities of this programme and the entire University of London, I have also been able to make great friends and learn from international experts in their various fields such as Allen Foster, Peter Piot, Andy Haines, Vikram Patel, Richard Horton, among others.

Studying this programme at LSHTM at the time of the COVID-19 pandemic put pressure on me to refine my skills as a researcher as the production of evidence at such a difficult time globally required me to plan, research, publish and implement new evidence in medicine and public health with urgency and with high quality.

Taught component

The first part of the DrPH focused on two core courses: *Evidence Based Public Health Policy* (EBPHP) about public policy implementation, and the course *Understanding Leadership, Management and Organisations* (ULMO) explaining leadership and management theory.

The first work I did for EBPHP was a Knowledge Transfer & Influencing Strategy. This work was entitled "Getting Mental Health Care into policy agenda in Mexico from the perspective of Partners in Health Mexico". Before starting my DrPH, I was Chief Operating Officer at Partners in Health Mexico for four years, located in the poorest region of Mexico (in the State of Chiapas). Among all the health and social development problems in Mexico and in this region, one of the most important is without a doubt, mental health. For this assignment, I focused on building recommendations addressed to PIH to put the issue of mental health on the political agenda in Mexico. For this work, it was necessary to learn and use tools such as the graphical illustration of the theories of change and problem trees; identifying the Actor Power through Stakeholder maps; and the assessment of the political context through the Leicester Framework. PIH Mexico received this work well and it was used to formalise and improve the organisation's mental health programme.

The second assignment focused on learning the skills in building a quality systematic review. For this, I collaborated on a real systematic review that the school was conducting at the time. My paper was entitled: "Effectiveness of ambulatory Point-of-care C-reactive protein testing to guide antibiotic prescriptions for respiratory tract infections: Systematic Review". The second part of this assignment was to learn how to produce a quality policy brief based on the results of this systematic review, for which I did the paper entitled "Policy brief: Introduction of C-reactive protein as point-of-care testing for respiratory infections to improve antibiotic use in primary care settings".

Regarding ULMO, the main assignment was on a strategic analysis for an organisation. In my case I looked at Partners in Health Mexico. For this work I evaluated the internal situation of the organisation based on the McKinsey 7-S framework, and in addition I evaluated and mapped the performance and external environment of the Organisational Performance Index. In the end this work allowed me to offer specific recommendations to the organisation, which were very well received by the Board of Directors.

Organization and Policy Analysis (OPA)

I have always had a great interest in eye health, particularly in Mexico, as it is a subject that has not been given the importance it deserves. That is why I focused the OPA and the Thesis on this subject.

Based on the skills learned in the taught component, the OPA involved conducting a Strategic Analysis of the programme *Del Amor Nace la Vista* of Cinepolis Foundation in Mexico. This programme provides cataract surgeries to socio-economically vulnerable people in Mexico, particularly in rural regions.

This was a 12,000-word paper which addressed 3 objectives:

- To understand the rationale for the creation of the programme.
- To assess the current internal management components of the programme through the use of The McKinsey 7-S framework.
- To evaluate the performance of the programme through the use of the Organisational Performance Index.

This work was well received by the board of the Cinepolis Company and was used in restructuring of the programme. Notably, this was the first report with medical, epidemiological, and strategic components that the programme had received.

Thesis

Finally, all this experience allowed me to decide that my Thesis would investigate a second eye problem of relevance in Mexico, that is diabetic retinopathy. Although Mexico has a high prevalence of diabetes, the issue of diabetic retinopathy has not been a national priority.

Based on the professional trust I enjoy with the health authorities of the State of Hidalgo, the proposal arose to assess the public health system for diabetic retinopathy with the aim to provide recommendations to strengthen the health system for the prevention of blindness and the delivery of comprehensive eye care services for persons with diabetes.

I have no doubt that this Thesis integrates all that has been learned throughout the DrPH. Furthermore, I am confident that this work will be of real value to the health authorities in Hidalgo.

Concluding thoughts

This work closes a precious learning cycle in my professional development. I am very grateful for all that I have learned and that this programme has made available a wealth of resources to enhance the learning experience.

Additionally, I would like to reflect that this programme has helped me to improve the work I am currently doing in Mexico, particularly during the COVID-19 pandemic. A reflection of this personal progress can be seen in the publications achieved during this period, in particular I would like to highlight the first papers I was able to write as first author,[1,2] and the lessons we have been able to publish from the experience of running the COVID-19 temporary hospital in Mexico City.[3,4]

References:

1. Martinez-Juarez LA, Sedas AC, Orcutt M, Bhopal R. Governments and international institutions should urgently attend to the unjust disparities that COVID-19 is exposing and causing. E Clinical Medicine 2020; 23: 100376.
2. Martínez-Juárez LA, Álvarez-Hernandez D-A, Sedas AC, Spencer J, Piot P. Defeating neglected tropical diseases in our new world living with COVID-19. Ther Adv Infect Dis 2020; 7: 204993612097197.
3. RRV V, H G-R, J L-G, et al. Impact of pre-emptive hospitalisation on health outcomes at the temporary COVID-19 hospital in Mexico City: a prospective observational study. Ther Adv Infect Dis 2021; 8. DOI:10.1177/20499361211040325.
4. AP C, ES L, MG N, et al. High-flow nasal cannula therapy for hypoxemic respiratory failure in patients with COVID-19. Ther Adv Infect Dis 2021; 8. DOI:10.1177/20499361211042959.

Tables

Figures

Boxes

Abbreviations

ACE2	Angiotensin-converting enzyme
ADA	American Diabetes Association
Anti-VEGF	Anti-vascular endothelial growth factor
ARDS	Acute respiratory distress syndrome
BMI	Body Mass Index
CENAPRECE	National Centre for Preventive Programs and Disease Control (In Spanish: *Centro Nacional de Programas Preventivos y Control de Enfermedades*).
CENETEC	National Centre of Technological Excellence in Health (In Spanish: *Centro Nacional de Excelencia Tecnológica en Salud*)
CFR	Case Fatality Rate
CI	Confidence Intervals
CSMO	Clinically significant macular oedema
CONAPO	National Population Council (In Spanish: *Consejo Nacional de Población*).
CONEVAL	National Council for the Evaluation of Social Development Policy (In Spanish: *Consejo Nacional de Evaluación de la Política de Desarrollo Social*).
COVID-19; COVID	SARS-Cov-2; Coronavirus-2019
DALY	Disability-adjusted life years
DM	Diabetes Mellitus
DMO	Diabetic Macular Oedema
DR	Diabetic Retinopathy
ENSANUT	National Survey of Health and Nutrition (In Spanish: *Encuesta Nacional de Salud y Nutrición*)
GDM	Gestational Diabetes Mellitus
GDP	*Gross domestic product*
GP	General Practitioner
HbA1C	Glycosylated haemoglobin
ICO	International Council of Ophthalmology
IDF	International Diabetes Federation
IDH	Institute of Health Data
IGT	Impaired Glucose Tolerance
IMSS	Mexican Social Security Institute (In Spanish: *Instituto Mexicano del Seguro Social*)
INEGI	National Institute of Statistic and Geography (In Spanish: *Instituto Nacional de Estadística y Geografía*)
NAC	North American and Caribbean
NCD	Non-communicable disease
NGO	Non-governmental organization
NOM	National Official Mexican Standards
NPDR	Non-proliferative Diabetic Retinopathy
OCDE	Organization for Economic Co-operation and Development

OR	Odds Ratio
OGTT	Oral Glucose Tolerance Test
PDR	Proliferative Diabetic retinopathy
PLWD	People Living with Diabetes
PPP	*Purchasing power parity*
TADDS	Tool for the assessment of diabetic retinopathy and diabetes management system
T1D	Type-one Diabetes
T2D	Type-two Diabetes
UNEME	Unit of Medical Speciality
US$	US Dollars
UKPDS	UK Prospective Diabetes Study
VTDR	Vision-Threatening Diabetic Retinopathy
WHO	World Health Organization
SIC	National Information System on Chronic Diseases (In Spanish: *Sistema Nacional de Información en Enfermedades Crónicas*).

1. Background

1.1. Diabetes Mellitus

1.1.1. Definition, Importance, and Classification

Diabetes Mellitus (DM) is defined by the World Health Organization (WHO) as a group of metabolic disorders that share the common feature of hyperglycaemia.

It is considered one of the priority non-communicable diseases (NCD) and one of the ten top causes of mortality worldwide.[1] In 2019, the International Diabetes Federation (IDF) reported 4.2 million deaths due to DM.[2]

DM is also a major cause of disability (e.g. amputations, visual loss), due to the involvement of various organs in the body. According to the last Global Burden of Disease 2019 Report, the burden attributed to Diabetes (all ages) rose from 20th in the leading causes of diseases in 1990 to 8th in 2019.[3] Other authors also describe an increase in the Global Disability-Adjusted Life Years (DALYs) from 1990 to 2017 of 116%.[4] An analysis by the Institute of Health Data (IHD) of the University of Washington reports that the Global DALYs attributed to Diabetes (all ages) in 2019 was 70,880,154 (95% CIs 59,707,574 - 84,174,005).[5]

The main types of DM are:

1. Type 1 Diabetes (T1D) is a condition characterised by a deficiency of insulin due to the destruction of pancreatic B-cells.[6]
2. Type 2 Diabetes (T2D) is a consequence of a progressive loss of adequate insulin secretion, together with insulin resistance at the cellular level.[7]
3. Gestational Diabetes (GDM) or hyperglycaemia of pregnancy, is Diabetes that appears during pregnancy (gestation) in a woman without previous Diabetes. GDM can affect both the mother and the baby's health. This type of Diabetes usually appears in the second to third trimester of pregnancy due to hormonal changes[7,8] . GDM usually resolves after the birth, but long-term consequence is an increased risk for Type 2 diabetes.
4. "Secondary" Diabetes attributed to other causes such as monogenic Diabetes syndromes, diseases of the exocrine pancreas, and drug- or chemical -induced Diabetes.[6]
5. Pre-Diabetes or Impaired Glucose Tolerance (IGT) refers to blood glucose levels above normal but not high enough to be called T2D (Table 1).

Historically, T1D was referred to as juvenile-onset Diabetes, and T2D as adult-onset Diabetes; however, T2D onset in young people is becoming increasingly important in some countries.[6]

1.1.2. Symptoms

The following are the main symptoms of Type 1 and 2 Diabetes:[6,10]

1. Excessive thirst and dry mouth
2. Frequent urination
3. Lack of energy, tiredness, drowsiness
4. Slow-healing wounds
5. Recurrent infections in the skin
6. Blurred vision
7. Tingling or numbness in hands and feet.

However, the presence of any of these symptoms alone cannot diagnose the disease, which can only be confirmed by measuring blood sugars.[10]

1.1.3. Diagnosis

The diagnosis of DM or Pre-diabetes is made by measuring blood glucose levels under different circumstances. Table 1 shows the different diagnostic criteria according to the 2020 Guidelines of the American Diabetes Association (ADA).[6]

Oral glucose tolerance curve with a loading dose of 75 grams (OGTT)

The OGTT is a two-hour test that measures blood glucose levels before and two hours after taking 75 mg of glucose in a 150 ml solution. The purpose of this test is to determine the rate at which the body metabolises glucose.[11]

Glycosylated haemoglobin (HbA1c)

This is a blood test for T2D and Pre-Diabetes. This test is a measure of the average level of glucose in the blood over the past three months. This test can be used to establish a diagnosis or to monitor the disease's therapeutic management.[11]

Table 1 describes the criteria for diagnosis of Diabetes and Pre-Diabetes in the non-pregnant adult population.[6]

Table 1. Diagnostic criteria for Diabetes in the non-pregnant adult population

Test	Normal Values	Pre-Diabetes	Diabetes
Fasting plasma glucose	<100 mg/dL	≥100-125 mg/dL	≥126 mg/dL
Oral glucose tolerance curve with charge of 75 grams (OGTT)	2-h OGTT <140 mg/dL	2-h OGTT: ≥140-199 mg/dL	2-h OGTT ≥ 200 mg/dL
Glycosylated haemoglobin (HbA1c)	<5.7%	5.7 to 6.4%	≥ 6.5%

2-h OGTT: The value of blood glucose at 2 hours after intake of 75 grams of glucose.

A diagnosis of DM can also be made with a random plasma glucose ≥ 200 mg/dL in the presence of symptoms related to Diabetes.

1.1.4. Prevalence and Magnitude of Diabetes

The prevalence of DM varies by age, region, country and urban / rural populations.[2] In 2019, the IDF estimated a global prevalence of 9.3% among adults over 18 years with 463 million people in the world having DM. This figure is projected to increase due to an increase in prevalence of DM,[12] and global population, to 700 million people with DM by 2045. T2D is the commonest form of DM.[2]

1.1.5. Risk factors

The following risk factors are associated with T2D:[13]

Modifiable

- High sugar / carbohydrate diet
- Sedentary lifestyle (low exercise)
- Hypertension
- Low values of HDL cholesterol and/or high levels of triglycerides
- Body mass index ≥25 kg/M^2
- Smoking

Non-modifiable

- Age
- History of Diabetes Mellitus in parents or siblings
- Having the diagnosis of Polycystic Ovary Syndrome (in women)
- History of Gestational Diabetes (in women)

1.1.6. Prevention of Diabetes Mellitus

The prevention of DM focuses on lifestyle and behavioural interventions. Among the most important are:

1. Weight reduction. In people with obesity DM can be prevented or its onset delayed if they manage to significantly reduce their weight. The objective for the patient with DM is to reduce 1-2 pounds/week (450-900 gr/week) by reducing 500-1000 Kcal/day based on the initial Body Mass Index (BMI) until achieve a BMI $\leq$25 kg/M^2.[14]
2. Reduction of sedentary periods is associated with a decrease in postprandial glucose levels.[15]
3. Performing physical activity 150 minutes/week at moderate to intense intensity improves insulin sensitivity and reduces abdominal fat.[16]
4. Smoking cessation. Tobacco has been linked to a higher risk for the onset of DM and complications like DR.[17]
5. Metformin has been identified as a cost-effective intervention to prevent the progression of Pre-Diabetes to DM.[18]

1.1.7. Treatment of Diabetes Mellitus

Treatment of a patient living with DM should follow a patient-centred approach particularly in view of the many organs / systems that can be involved.

Main recommendations for the treatment of T2D

Based on the latest version of the ADA Standards of Medical Care in Diabetes 2021,[18] the management is based on pharmacological and non-pharmacological strategies.

First, changes in lifestyle must be made (smoking, diet, and exercise), as mentioned in the previous section.

The second line of intervention is pharmacological treatment. It is necessary to consider risk of adverse effects of each drug, safety, tolerability, accessibility, and cost before starting any drug treatment. Once these points have been determined, it is important to establish glycaemic control goals depending on each patient's circumstances.

The control level (glycaemic target) to achieve is a pre-prandial glucose between 80-130 mg / dL or HbA1C less than 7%.

The first-line treatment is Metformin, which is recommended to be used for as long as possible. Its use is also recommended with other medications according to the therapeutic strategy for each patient.

Different types of insulin can be used when the blood glucose levels are $\geq$300 mg / dL or HbA1C levels> 10%.

There are other pharmacological strategies for patients with associated cardiovascular disease, or kidney disease.

Main recommendations for the treatment of T1D

According to the Standards of Medical Care in Diabetes 2021,[19] Insulin continues to be the treatment of first choice. There are two types of insulins, analogues and human, and these are classified by the time of action, specifically, how quickly they start to work, when they have a maximum effect, and how long they work.

Compared with human insulins, the use of insulin analogues is associated with a lower risk of hypoglycaemia, lower weight gain, and greater reduction in HbA1c than human insulin.

When choosing between insulin delivery systems, the patient preferences, cost, insulin type and dosage regimen, and ability to self-manage should be considered.

1.1.8. Complications due to Diabetes Mellitus

Chronic exposure to elevated sugar levels can result in damage to different organs. Chronic hyperglycaemia leads to blood vessel damage as endothelial cells absorb more glucose than normal (this process is not insulin-dependent). The result is both "microvascular disease" (due to damage to small blood vessels) and "macrovascular disease" (due to damage to arteries).

The more common complications are ischemic heart disease, stroke, lower limb ischaemia leading to amputations, renal failure and diabetic retinopathy leading to visual loss and blindness. Diabetes has also been associated with an increased risk of cognitive dysfunction and dementia through disease processes such as Alzheimer's disease and vascular dementia.[20,21]

1.1.9. Economic costs

The IDF estimates that the annual global health expenditure on DM is $750 billion dollars, and it is estimated to increase to $845 billion dollars for 2045.[2]

The information on the economic impact of DM in Mexico is limited. The National Health and Nutrition Survey (ENSANUT) of 2012, estimated the annual cost of DM care (in adults) to be $3,872 million dollars.[22]

A recent analysis (2015) by Barcelo et al. on the total cost (direct and indirect) attributable to Diabetes in Latin America and The Caribbean (LAC) estimated it to be between US$ 102-123 billion. On average, the annual cost of treating one case of diabetes mellitus in LAC was estimated to cost US$ 1,088 – 1,818, with the average total per capita expenditure on National Health being only US$ 1,061 in LAC.[23]

1.2. Diabetic Retinopathy

DM can affect the vision in different ways. The main complications are change in refractive error, cataract, and diabetic retinopathy (DR). Diabetes is also considered a risk factor for open angle and neovascular glaucoma. However the main threat to vision in people living with DM is DR.[24,25]

DR is asymptomatic in the first stage of the disease; however, as the disease progresses, macular oedema, and complications of new vessel formation (proliferative disease) can lead to vision loss.[26]

1.2.1. Pathophysiology

Chronic hyperglycaemia results in biochemical and histological changes in the micro-vasculature of the retina. Damage to the endothelium of capillaries in the retina causes leakage of fluid or blood, and or lead to capillary closure producing ischaemia of the retina. Ischaemia leads to the release of vascular endothelial growth factors (VEGF), triggering new blood vessels to proliferate in the retina.

Neovascularisation can bleed or generate a fibrotic process, resulting in vitreous haemorrhage and / or retinal detachment.[26,27]

1.2.2. Clinical Signs

The following signs may be seen in the retina

1. Microaneurysms: dilations of small vessels.
2. Hard exudates: Increased permeability of the capillaries of the retina result in an outflow of fluid from the vessels generating protein deposits in the retina.
3. Macula oedema: Increased permeability of the capillaries around the macula result in an outflow of fluid and oedema, resulting in a reduction of central visual acuity.
4. Cotton wool spots: Obstruction of the capillaries and arterioles resulting in ischaemia to the retinal cells.
5. New blood vessels: The proliferation of new (abnormal) vessels occurs at the vitreo-retinal interphase, are fragile, bleed easily affecting vision.
6. Haemorrhages can occur from new vessels into the retina or into the vitreous.
7. Fibrous tissue / retinal detachment; fibrosis of new vessels causes traction on the retina resulting in retinal detachment.

1.2.3. Classification

The International Council of Ophthalmology (ICO) classification of DR is used in Mexico. It describes the different stages of the disease according to its severity and respective clinical management.[28]

Tables 2, 3 and Figure 1 shows the ICO's classification for DR.[28,29]

Adaption from the ICO Guidelines for Diabetic Eye Care of 2017.

Table 2. ICO's classification of Diabetic Retinopathy

Diabetic Retinopathy		Observable findings
1	No apparent DR	No abnormalities
2	Mild non-proliferative DR	Microaneurysms only
3	Moderate non-proliferative DR	Microaneurysms and other signs (e.g., dot and blot haemorrhages, hard exudates, cotton wool spots), but less than severe non-proliferative DR
4	Severe non-proliferative DR	Moderate non-proliferative DR with any of the following: • Intraretinal haemorrhages (≥20 in each quadrant); • Definite venous beading (in 2 quadrants); • Intraretinal microvascular abnormalities (in 1 quadrant); • and no signs of proliferative retinopathy
5	Proliferative DR	Severe non-proliferative DR and 1 or more of the following: • Neovascularization • Vitreous/pre-retinal haemorrhage

Diabetic Macular Oedema

An important complication is the presence of oedema at the macula. The macula is the central region in the retina specialised for vision of detail, so that oedema of the macula can reduce the visual acuity.

The ICO classifies Diabetic Macular Oedema (DMO) as central and non-central.

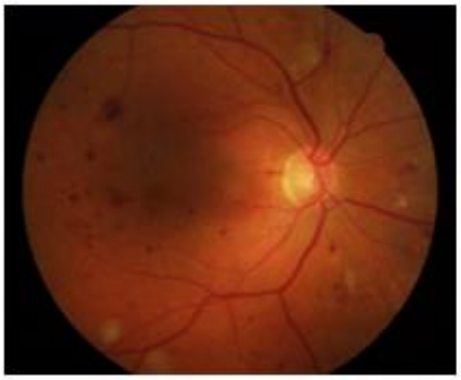
Table 3. ICO's classification of Diabetic Macular Oedema

Diabetic Macular Oedema (DMO)		Observable findings
1	No DMO	No retinal thickening or hard exudates in the macula
2	Non-central involved DMO	Retinal thickening in the macula that does not involve the central subfield zone that is 1mm in diameter
3	Central-involved DMO	Retinal thickening in the macula that does involve the central subfield zone that is 1mm in diameter

Figure 1. Retinal images showing classification of diabetic retinopathy

No diabetic retinopathy (Normal retina)

Moderate non-proliferative DR



Severe non-proliferative DR

Proliferative DR

Macular Oedema

Source: Comm Eye Health Vol. 28 No. 92 2015 pp 70 - 71. Published online 15 April 2016.

Publisher: International Centre for Eye Health, London School og Hyene and Tropical Medicine

1.2.4. Global Magnitude of Diabetic Retinopathy

A review by Yau of 35 studies (1980-2008) of 22,896 patients with DM estimated that 34.6% have DR, and 10.2% have vision threatening DR (VTDR).[30]

Cheng and Congdon in 2012 projected that the number of persons with DR will increase from 126.6 million in 2011 to 191.0 million by 2030, and the number of people with severe VTDR will increase from 37.3 million to 56.3 million in the absence of adequate public health strategies.[31]

A more recent review by Teo et al (2021) undertook a systematic review of 59 population-based studies published up to March 2020 to estimate the global and regional prevalence of DR, vision-threatening DR (VTDR),[32] and clinically significant macular oedema (CSMO). The results showed a global prevalence of 22.3% (95% confidence interval [CI], 19.7%-25.0%) for DR, 6.2% (95% CI, 5.4%-7.0%) for VTDR, and 4.1% (95% CI, 3.4%-4.8%) for CSME. Using International Diabetes Federation (IDF) estimates for the global population with DM to be 463 million in 2019 and 700 million in 2045, they estimated that in 2020, the number of adults worldwide with DR, VTDR, and CSMO was approximately 103 million, 28.5 million, and 18.8 million, respectively; and by 2045, the numbers are projected to increase to 160 million, 45 million, and 28 million, respectively. Diabetic retinopathy and VTDR was reported to be present in 33.3% and 7.8% respectively of diabetics in North America including Mexico. It was also reported that Hispanics were more likely to develop DR than other ethnic groups (odds ratio [OR], 2.92; 95% CI, 1.22-6.98) compared with Asians.

1.2.5. Prevention of Diabetic Retinopathy

The main modifiable risks factors that influence the prevention and control of DR are:

- controlling blood glucose,
- controlling blood pressure,
- lowering serum lipid levels,
- lowering body mass index,
- stopping smoking.[33]

It is important to stress that the control of blood glucose is considered the most influential factor for progression of the disease.[34]

The UK Prospective Diabetes Study (UKPDS, 1999) showed an important correlation among the presence of microvascular changes and the levels of blood glucose, so that for every percentage point of HbA1c decrease, the risk of microvascular complications dropped by 35%.[35] This study showed that strict control of blood sugar reduced the risks of progression of retinopathy by about a third, visual loss by half and the need for laser treatment by a third in people with type 2 Diabetes.[35]

1.2.6. Screening for Diabetic Retinopathy

The key requirements for a successful DR screening programme include patient awareness and compliance, a test having high sensitivity and specificity,[36] and available effective treatment for those with diabetic retinopathy that threatens vision (VTDR).

The adoption of a screening programme must consider the local settings and conditions where the programme is to be established, particularly for low-income countries with limited resources.[37]

The key requirement of a DR screening strategy is to offer treatment according to the need of patients. Once this service is available, an opportunistic or systematic screening strategy can be established.[36]

The American Academy of Ophthalmology suggests to implement a diabetic eye screening programme according to the type of DM:[38]

- For patients with T1D, it is recommended to examine the eyes / retina five years after the onset of the disease, and depending on the findings at regular intervals thereafter.
- For patients with T2D, it is recommended to examine the eyes / retina at the time of diagnosis, and depending on the findings at regular intervals thereafter.
- Regarding DM in pregnancy, women who have diabetes in pregnancy should receive an eye-examination as early as possible.

Screening Test

The test for DR is examination of the retina for any of the signs of retinopathy. This can be done by taking a photograph of the retina using a fundus camera with the photograph being examined for signs of DR. The retina can also be examined with an ophthalmoscope (direct or indirect) or by slit lamp biomicroscopy through a dilated fundus.

Fundus pictures can be graded by trained graders. There are certified international training programmes available to train graders. Ophthalmologists and trained optometrists can examine the fundus with an ophthalmoscope and make a decision as to whether DR is present or absent.ICO Guidelines for how often to examine the retina and when to refer patients for further assessment and treatment are given in Tables 4 and 5.

Table 4. ICO Guidelines for re-examination and referral of DR

Diabetic Retinopathy		**Observable findings**	**Re-examination / next screening schedule**	**Referral to Ophthalmologist**
1	No apparent DR	No abnormalities	Re-examination in 1-2 year	Referral not required
2	Mild non-proliferative DR	Microaneurysms only	6-12 months	Referral not required
3	Moderate non-proliferative DR	Microaneurysms and other signs (e.g., dot and blot haemorrhages, hard exudates, cotton wool spots), but less than severe non-proliferative DR	3-6 months	Referral required
4	Severe non-proliferative DR	Moderate non-proliferative DR with any of the following: • Intraretinal haemorrhages (≥20 in each quadrant); • Definite venous beading (in 2 quadrants); • Intraretinal microvascular abnormalities (in 1 quadrant); • and no signs of proliferative retinopathy	< 3-months	Referral required
5	Proliferative DR	Severe non-proliferative DR and 1 or more of the following: • Neovascularization • Vitreous/pre-retinal haemorrhage	< 1 month	Referral required

Adaption from the ICO Guidelines for Diabetic Eye Care of 2017. [28,29]

Table 5. ICO Guidelines for re-examination and referral of DMO

Diabetic Macular Oedema (DMO)		Observable findings	Re-examination Or next screening schedule	Referral to Ophthalmologist
1	No DMO	No retinal thickening or hard exudates in the macula	3 months	
2	Non central-involved DMO	Retinal thickening in the macula that does not involve the central subfield zone that is 1mm in diameter	3 months	Referral required
3	Central-involved DMO	Retinal thickening in the macula that does involve the central subfield zone that is 1mm in diameter	1 month	Referral required

Adaption from the ICO Guidelines for Diabetic Eye Care of 2017. [28]

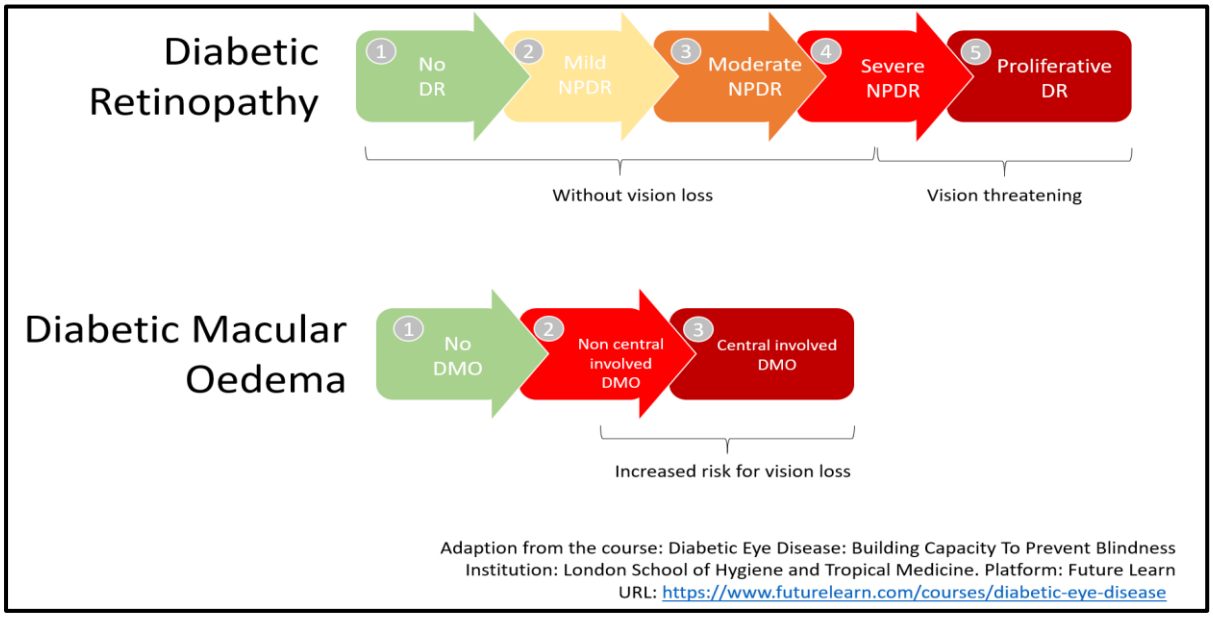
The implementation of screening strategies varies according to the available resources. Systematic screening of all DM patients on a regular basis is ideal, however in low resource settings this may not be feasible and opportunistic screening of patients attending for DM treatment may be appropriate.[39]

1.2.7. Treatment of Diabetic Retinopathy including Diabetic Macular Oedema

The different treatment options depend on the type of DR - proliferative or macula oedema (DMO).

Figure 2 shows the different stage of DR and DMO.[33]

Figure 2. Progressive Pathway of types of Diabetic Retinopathy and Diabetic Macular Oedema



The objective of treatment is to preserve vision and avoid loss of vision.

Treatment may be with medicines, laser, or surgery.

Medical treatment

Anti-vascular endothelial growth factor (anti-VEGF) inhibits the growth of new blood vessels, thereby preventing haemorrhage and oedema in the retina. This treatment is given by injecting the drug into

the vitreous of the eye[27]. A course of injections over several months or years is the treatment of choice for DMO.

Laser treatment

Laser photocoagulation (pan-retinal) is considered the treatment of first choice in patients with Proliferative DR (PDR).[26] A course of anti-VEGF injections may also be considered. Grid or focal laser to the peri-macula area may also be used in DMO.

Surgical treatment

Vitrectomy can be used to remove a vitreous haemorrhage and vitreo-retinal surgery with a variety of techniques may be considered for diabetic retinal detachment.

1.3. Health Care in Mexico

1.3.1. Country and Population

Mexico has a population of approximately 126 million people with 33 States and different geographical, sociocultural, and economic characteristics. Mexico is the 10th most populated country in the world. The metropolitan area of Mexico City has a population of approximately 20+ million. About 80% of the population live in urban areas. The Growth Rate is nearly 2% and Life Expectancy about 76years. Two thirds of the population are aged 15-64 and only 7% are 65 and over.[40, 41, 42]

Figure 3 shows the location of Mexico in the Americas and the political divisions of the country.

Figure 3. Location in the Americas and Political divisions of Mexico

a. Global location of Mexico.

Location of Mexico
by unknown, Wikipedia, Public Domain.[43]

b. Political divisions of Mexico.

Political division of Mexico,
by unknown, Wikipedia, Public Domain.[44]

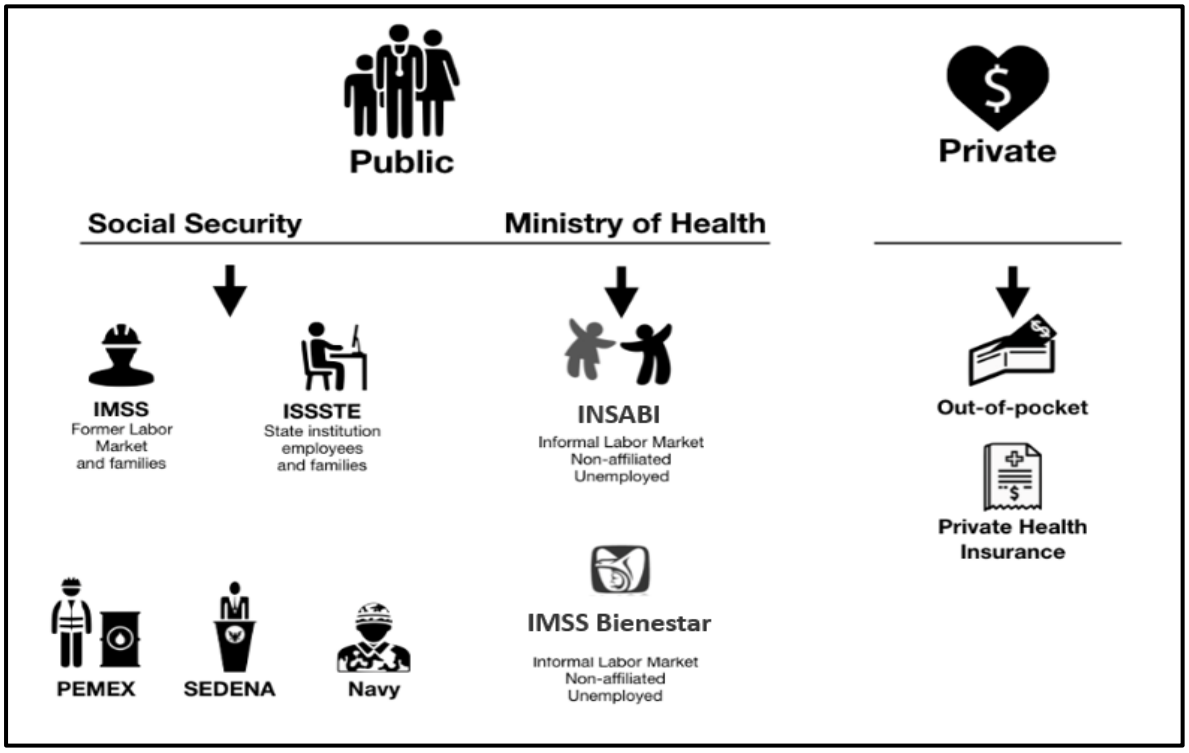
1.3.2. Health System in Mexico

The health system in Mexico consists of the public (Ministry of Health and Social Security) and the private sector.

The public sector consists of the Ministry of Health and Social Security providers, each with their staff, infrastructure, material resources, and administration. Those in the population who do not participate in the formal labour market receive health services through the Ministry of Health. Those who participate in the formal labour market, state employees and those affiliated to military or oil companies receive services through social security schemes. See Figure 4. The private sector provides health care for the Mexican community who are wealthy and can pay high out-of-pocket expenses to cover their medical needs.[45]

According to the National Institute of Statistics and Geography (INEGI by its acronym in Spanish); 62.1% of the population receive health services from social security institutions (attending only those who participated in the formal labour market); 35.5% receive health services from the public sector (not participating in the formal labour market) and less than 3% from private providers.[46]

Figure 4. Diagram of the Mexican Health Care System



The Social Security schemes includes:

a. The *Instituto Mexicano del Seguro Social* (IMSS),
b. *Instituto de Seguridad y Servicios Sociales para los Trabajadores del Estado* (ISSSTE),
c. *Petroleos Mexicanos* (PEMEX),
d. The Secretary of Defence (SEDENA)
e. The Navy (Marina).

The Private sector involves either direct out-of-pocket payment or private medical insurance.[45]

1.3.3. Mexican standards for Health Care (NOM)

The National Official Mexican Standards (NOM) are technical regulations issued by different agencies. The NOMs establish the processes or services to address risks to the safety of people or damage to human health.[47]

The National Consultative Committee approves the NOMs on Prevention and Health Promotion for the Prevention and Control of Diseases (CENAPRECE by its acronym in Spanish). They are reviewed every five years and are issued and published in the Federation's Official Gazette. The NOMs are to be followed from the day after they are published.

The **Official Mexican NOM [PROY-NOM-015-SSA2-2018] for the prevention, treatment and control of Diabetes mellitus** is the current normative document to provide services for Diabetes and its complications.[48] It sets out the framework of care that the health system in Mexico must follow; and thus, are considered regulatory in public health institutions in Mexico. These documents include:

1. The **clinical care algorithms for Type 2 Diabetes** issued by the National Centre for Technological Excellence in Health (CENETEC by its acronym in Spanish). These guidelines are developed in consensus with the country's main health institutions in collaboration with the Pan American Health Organization.[49]
2. **Clinical practice guide for the diagnosis and treatment of diabetic retinopathy**, issued by CENETEC in 2015.[50]
3. **Evidence and recommendations in diet therapy and food for patients with Diabetes mellitus,** issued by CENETEC and the Mexican Social Security Institute (IMSS by its acronym in Spanish) in 2015.[51]

An analysis of the contents of these guides is provided in the discussion section.

Concerning DR, the national regulatory framework of the Ministry of Health on the prevention, treatment and control of DM proposes to examine all patients with DM for DR at the time of diagnosis [48], without providing details on how to do it.

The 2014 national guidelines of the National Centre of Technological Excellence in Health (CENETEC by its acronym in Spanish) for the detection of DR at the primary level provides a flow chart for the diagnosis and treatment of DR;[52] however, there is no clinical guide about strategies to prevent, screen, diagnose or manage DR.

1.3.4. Human Resources for Eye Care in Mexico

Ophthalmologists are one member of the eye care team. According to the International Council of Ophthalmology report of 2015, the density of ophthalmologists varies greatly from one country to another. In low-income countries, there is often 1 to 5 ophthalmologists per million population, whereas for high-income countries there may be as many as 50-100.[53] In Mexico, it is reported that there are 26 to 37 ophthalmologists per million population,[54] with many of them being in the large cities such of Mexico City, Monterrey and Guadalajara.[55]

The WHO recommend one clinical refractionist (who may be an optometrist, ophthalmologist, optician, ophthalmic clinical officer, ophthalmic nurse or technician) for every 10,000 population. [56] Mexico is reported to have 59 optometrists per million population.[57] In Mexico optometrists provide refraction services in the private sector but at present are not given a formal role in eye care in the public sector e.g. screening for DR. Informally in some states such as Hidalgo, optometrists have participated in eye outreach campaigns and triaged patients for common eye conditions, however these campaigns are not standardised, and their implementation depends on the available resources of each regional health department.

1.3.5. Prevalence and Magnitude of DM and DR in Mexico

There are two reports of the prevalence of DM. The 2018 National Health and Nutrition Survey (ENSANUT in Spanish) reports a prevalence of 10.4% of Type 2 Diabetes in the adult population[58] with higher prevalence in women (11.4%) than men (9.1%); however, this figure only represents the prevalence of known Diabetes by the patient.

The IDF - Diabetes Atlas 2019 documents a prevalence of 13.5% for Mexico.[2] It is probable that the prevalence of Diabetes in Mexico published by IDF is more representative of Mexico's reality than ENSANUT, which underestimates the true prevalence as it fails to capture persons with Diabetes who are undiagnosed. For this reason, this thesis uses the information published by the IDF for descriptive text and estimations.

The following table shows the prevalence of DM for Mexico and countries in the region in 2010 and 2019 and their respective projection for 2030 and 2045.

Table 6. Prevalence of Diabetes % (20-79 years) in selected countries of Central and North America: Data for 2010, 2019, and estimations for 2030 and 2045

Country	2010 %	2019 %	2030 %	2045 %
Mexico	10.8	13.5	14.8	15.4
United States of America	10.3	10.8	12.1	12.8
Guatemala	8.6	10.0	11.0	11.5
El Salvador	9.0	8.8	9.7	10.1
Honduras	9.1	7.3	7.9	8.2

Information obtained from the IDF Diabetes Atlas 9th Edition 2019.[2]

This work considers for Mexico the same prevalence of DR in DM reported by Teo et al (2021) for the North American and Caribbean (NAC) region.[32] Table 7 shows estimates of the affected population with DM, DR and VTDR for the national population.

Table 7. Estimations of people with Diabetic Mellitus, Diabetic Retinopathy and Visual-Threatening Diabetic Retinopathy for Mexico

People	Calculation	Number
Total national population in 2020[59]		126 million
Prevalence of DM[2]	13.5 % (pop aged 20 yrs+)	-
% of population aged 20+ [59]	**66%**	**83 million**
Number with Diabetes	**13.5% of 83 million**	**11.229 million**
Number with DR[32]	**33.3% of 11.229 million**	**3.739 million**
Number with VTDR (PDR / DMO)[32]	**7.8% of 11.229 million**	**876,000**

1.4. Hidalgo

1.4.1. Hidalgo State and Population

Hidalgo is one of the thirty-two states of Mexico. It is located in the centre of the country, north of Mexico City, with an area of 20 813.57 km².[60]

Figure 5 shows the location of Hidalgo with respect to Mexico.

Hidalgo is made up of eighty-four municipalities, and the City of Pachuca is its capital. This State has a total population of 3.08million which represents 2.4% of the population of Mexico. Of those inhabitants, 52% are women, and 48% are men.[60,61]

The population distribution is: 52% urban and 48% rural.

The two most populated cities are the city of Pachuca with approx. 277,000 inhabitants, and the city of Tulancingo with approx. 161,000 inhabitants.

Figure 5. Map of Mexico indicating the location of the State of Hidalgo

Geography of south-central Hidalgo and north-eastern Mexico, Mexico, by unknown, Wikipedia, Public Domain.[62]

Figure 6. Location of Pachuca and Tulancingo in the Map of Hidalgo

Black map of Hidalgo by unknown, Wikipedia, Public Domain.[63]

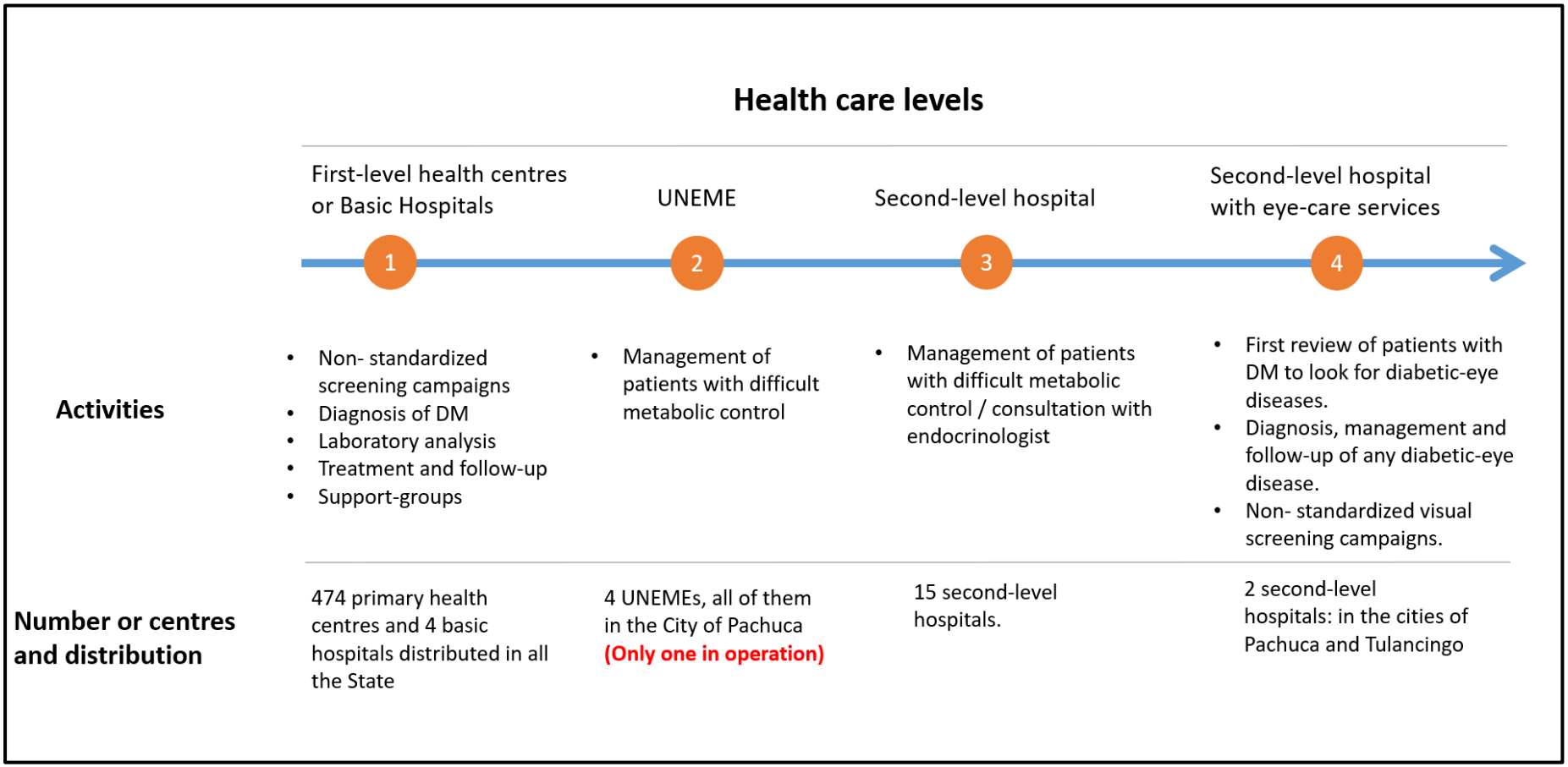
1.4.2. Health Facilities in Hidalgo

The public health centres and hospitals involved in the care of DM and DR in Hidalgo are the following:

- First-level / **primary health centres** distributed in all the State (n=474, approx. 1 / 6,500 population).
- **Basic hospitals**, which are primary health centres that provide ambulatory, emergency, and short-term hospitalisation (n=4).
- **Units of Medical Specialty Care** (UNEME by its acronym in Spanish), which are ambulatory centres focused on the management of DM, hypertension, and obesity. All of them are in the City of Pachuca. There are meant to be 4 UNEMES, however just one is in operation.
- **Second-level (general) hospitals**, which provide ambulatory health care and hospitalisation in the four primary specialties and some subspecialties. (n=15, 1/ 205,000 pop). Two of these 15 hospitals provide eye-care services (1 / 1.5 million pop): The second-level hospital of Pachuca and Tulancingo.

Figure 7 shows diagrammatically the public health centres and hospitals involved in the continuum of care for DM and DR.

Figure 7. Summary of the continuum of care for Diabetes Mellitus and Diabetic-eye disease in the public health system of Hidalgo



Patients with DM can seek medical attention in public or private services. Within the public sector, the patient should attend an initial consultation with a general practitioner (GP) in a public primary health centre or basic hospital who will make a diagnosis, provide treatment, and follow-up.

In some of these primary health centres and basic hospitals, patients have the opportunity to attend mutual support groups, which are group sessions guided by a health professional with the purpose of addressing topics related to changes in lifestyle, disease treatment, prevention of complications, and to generate support among patients.

Those patients with difficult metabolic control are referred to the endocrinologist in one of four UNEMES in the City of Pachuca (the Capital).

1.4.3. Prevalence and Magnitude of DM and DR in Hidalgo

Hidalgo is one of the 33 States located in the centre of the country and with a population of 3.1 million people and a high level of social deprivation.[61]

According to the National Survey of Health and Nutrition of 2018 (ENSANUT), the prevalence of DM in 2018 was 12.8% in the State of Hidalgo.

According to these figures, approx. 90,540 people living with Diabetes have DR, and approx. 21,207 have PDR or DMO (VTDR).

Table 8. Estimations of people with Diabetic Mellitus, Diabetic Retinopathy and Visual-Threatening Diabetic Retinopathy for the State of Hidalgo

People	Calculation	Number (approximate estimate)
Total state population in 2020 [59]		3.082 million
Prevalence of DM [2]	13.5 % (in pop aged 20 yrs+)	
% of population aged 20+ [59]	**65.4%**	**2.014 million**
Number with Diabetes	**13.5% of 2.015 million**	**272,000**
Number with DR[32]	**33.3% of 272,000**	**90,500**
Number with VTDR (PDR / DMO)[32]	**7.8% of 272,000**	**21,200**

1.4.4. Eye Health services in Hidalgo

In practice, when a person with DM is diagnosed, first-level GPs refer patients to one of the two second-level hospitals that provide eye-care services in the State. The centralisation of these services overloads the system and patients with DM can wait a considerable length of time for their ocular assessment.[64] If a patient has DR in principle they should receive treatment and follow-up at one of these two second-level eye clinics in hospitals, but because of limited resources in the public sector patients with financial resources usually seek treatment in the private sector.[64]

1.5 COVID 19 and Diabetes

1.5.1 COVID-19: The disease

The SARS-Cov-2 (coronavirus-2019 [COVID-19]) disease is caused by a RNA Coronavirus. The first human case was detected in December 2019 in the city of Wuhan in China. On March 11, 2020 the WHO declared this new disease as a pandemic.[65,66]

The transmission of the disease is airborne spread through droplets.[67, 68]

The clinical presentation of COVID-19, varies with between 20% -75% of infected people being asymptomatic.[69,70] The most common symptoms are fever, cough, myalgia, and fatigue, sometimes with loss of smell or taste.[71,72]

According to the Johns Hopkins University and the University of Oxford, the global case fatality rate (CFR) as of April 17, 2021 is 2.1%, however this figure varies according to age, gender, ethnicity, comorbidity and country.[73,74]

COVID-19 disease is being studied in populations according to:

- Acute phase (during the first 30 days from the onset of symptoms) where acute respiratory distress syndrome (ARDS), multiorgan failure, sepsis, bacterial pneumonia are important.[75]

- Chronic phase: This refers to those long-term health consequences related to the COVID-19 disease present after its acute phase, and which are not associated with consequences inherent in hospitalisation or the use of invasive mechanical ventilation or hospital treatments.[76,77]

At the beginning of the pandemic the priorities in public health included identification of risk factors for infection, hospitalisation, and mortality. As the pandemic has developed the importance of measures to reduce transmission, treat acute cases and prevent infection through vaccination have become important. However, new challenges continue emerging as more is known about this disease. Two new priorities in public health are:

1. Understanding and addressing the long- term effects of COVID-19, so called “long COVID”.
2. Understanding the impact of COVID 19 on health services for other diseases. For example, the impact of COVID 19 on the capacity to screen, diagnose, and manage NCDs, including DM. (See section 3.3 for more detail).

1.5.2. COVID-19: Global numbers

Up to April 17, 2021, according to the WHO, the London School of Hygiene and Tropical Medicine and Johns Hopkins University the global number of COVID-19 cases is estimated at 139 million with nearly 3 million deaths.[73,78,79] Regional data from the WHO COVID-19 dashboard are reported in Table 9.

Table 9. Number of confirmed cases and deaths by WHO region by April 17, 2021

Region	Number of confirmed cases	Number of deaths
Americas	59,294,109	1,438,618
Europe	48,987,035	1,032,338
South-East Asia	17,423,545	236,088
Eastern Mediterranean	8,396,854	169,805
Africa	3,214,868	80,545
Western Pacific	2,184,778	34,786

1.5.3. COVID-19 in Mexico

The first case of COVID-19 in Mexico was registered at the end of February 2020. Since then until April 17, 2021, The Ministry of Health has registered 2,490,643 cases and 211,603 deaths.[80]

Table 10 shows the number of cases and deaths by gender and with comorbidities - Hypertension, Diabetes and Obesity for Mexico (a) and for the State of Hidalgo (b).

Table 10. Distribution of COVID-19 cases and deaths by sex and comorbidity in Mexico and Hidalgo (April 17, 2021)

a. Mexico

Category	Reported Cases	Reported Deaths
	Number	Number
Cases	2,490,643	211,693
Sex	**%**	**%**
Male	51%	63%
Female	49%	37%
Comorbidity	**%**	**%**
Hypertension	17%	45%
Obesity	14%	21%
Diabetes	13%	37%

b. Hidalgo

Category	Reported Cases	Reported Deaths
	Number	Number
Cases	37,585	5,982
Sex	**%**	**%**
Male	53%	65%
Female	47%	35%
Comorbidity	**%**	**%**
Hypertension	21%	45%
Obesity	18%	23%
Diabetes	17%	38%

Based on the figures published by the University of Oxford (April 17, 2021), the CFR in Mexico is 9.2%, which is much higher compared with the global CFR of 2.1%.[81,82]

The CFR figures on mortality do not include the increased mortality caused indirectly by the COVID pandemic. According to Karlinsky & Kobak, Mexico had the 4th highest excess mortality with overall 43% more deaths in 2020 than would have been expected according to the average for 2018-2019 (pre-COVID).[83]

A recent case study from the University of California reported an excess mortality in Mexico between April 12, 2020 and January 2, 2021 of 308,190 deaths, that is 2.6 times the number of deaths reported due to COVID-19 for the same period.[84] This figure includes the direct and the indirect impact that COVID has had on mortality during this period of the pandemic in Mexico. The same report points out that one of the main reasons for the excess mortality is due to the partial disruption of the health system in order to focus on care for the COVID-19 pandemic. Moreover, this effect has been most pronounced in the Mexico City metropolitan area, which has a population of more than 20 million people.

1.5.4. COVID-19 severity and mortality in persons with Diabetes

The role of DM as a risk factor for severe COVID-19 disease has gained importance during the pandemic. Several studies have reported an association between severity of COVID-19 and DM, as well as hypertension, cardiovascular disease and obesity.[85–90]

The risk of severe COVID-19 or death in those with DM has been described since the beginning of the pandemic in Wuhan. A study published by Shi and Colleagues reported that of 1,562 patients with COVID-19 in two hospitals in Wuhan, the risk of admission to the Intensive Care Unit or death was higher in those with Diabetes.[91]

A study in the United Kingdom by Holdman et al. analysed the risk of death in patients with Type 1 and 2 Diabetes at the time of admission to hospital due to COVID-19. This study reported an increased risk of death in patients with DM who had HbA1C greater than 10.0% compared to those with an HbA1C level between 6.5% and 7.0%.[92]

A meta-analysis published by Guo et al in China reported an increased risk of severity or death from COVID-19 in those people with DM of 2.96 (95% CI: 2.31–3.79).[90] A systematic review and meta-analysis by Degarege et al. calculated an Odds Ratio (OR) for severe COVID-19 disease of 1.65 (95% CI 1.23–2.08) in comparison with COVID patients without Diabetes.[93] This poor prognosis depends on different factors such as age, sex, other comorbidities like hypertension and obesity, and pro-inflammatory and pro-coagulative states as described by Apiccela and colleagues.[94] Specifically, glucose and pro-inflammatory cytokine levels are higher in patients with DM and obesity compared to people who do not have these conditions [95]. This is important as these factors are associated with angiotensin-converting enzyme (ACE2) activity, which affects the severity of COVID-19 infection.[96] Therefore control of hyperglycaemia and blood pressure are important to reduce the severity of COVID-19 disease,[95] and it is essential to improve the management of NCDs at all levels of health service delivery to reduce the mortality from COVID-19.

1.5.5. Impact of COVID 19 pandemic on DM and DR services

It is important to consider and analyse how the pandemic has impacted the provision of services for people living with DM. A WHO survey carried out in 2020 in 163 countries, reported that 49% of countries have partially or totally suspended care services for DM and DM-related complications.[97]

The different reasons for the suspension of services for people living with DM will be discussed in the discussion section. However, it should be noted that the limited access to medical care, medicines and technologies for people living with DM limits the ability to detect and control the disease and its complications.[97] As a consequence one could expect an increase in poor control of DM and therefore more DM complications .

2. Study Description and Methods

2.1. Problem statement

The burden of DM disease in Mexico is considerable with approximately 1 in 7 of the adult population (13.5% aged 20 yrs. and over) having the disease.[2] In the State of Hidalgo, it is estimated that of the 272,000 people with DM approximately 90,500 people have DR, of which an estimated 21,200 people have DR requiring immediate treatment (Table 8). The inadequate provision of eye care services in the public sector is exacerbated in the State of Hidalgo by having only two public secondary hospitals with ophthalmology services, although there are 35 certified ophthalmologists in the State.[98] Because of the large number of PLWD in Hidalgo and the estimated numbers at risk of blindness due to visually threatening DR it is important to assess the public health system for DR screening, diagnosis, and treatment services to provide recommendations to the Minister of Health on how to improve these services and prevent avoidable blindness.

Before the COVID-19 pandemic, articles in the scientific literature stressed the importance of enhancing eye care services in the public sector for people living with DM (PLWD).[64,99,100] Surveys from the WHO in 163 countries report that following the COVID pandemic 49% of countries have partially or totally suspended care services for DM and Diabetes-related complications[97], however the impact of COVID on services for DM / DR in Hidalgo is undocumented.

2.2. Aim of the study

The aim of this study was to assess the public health system for DM/DR services in the State of Hidalgo, identify the constraints resulting from the COVID-19 pandemic, and provide recommendations to maintain and strengthen the health system for the prevention of blindness and the delivery of comprehensive eye care services for persons living with DM.

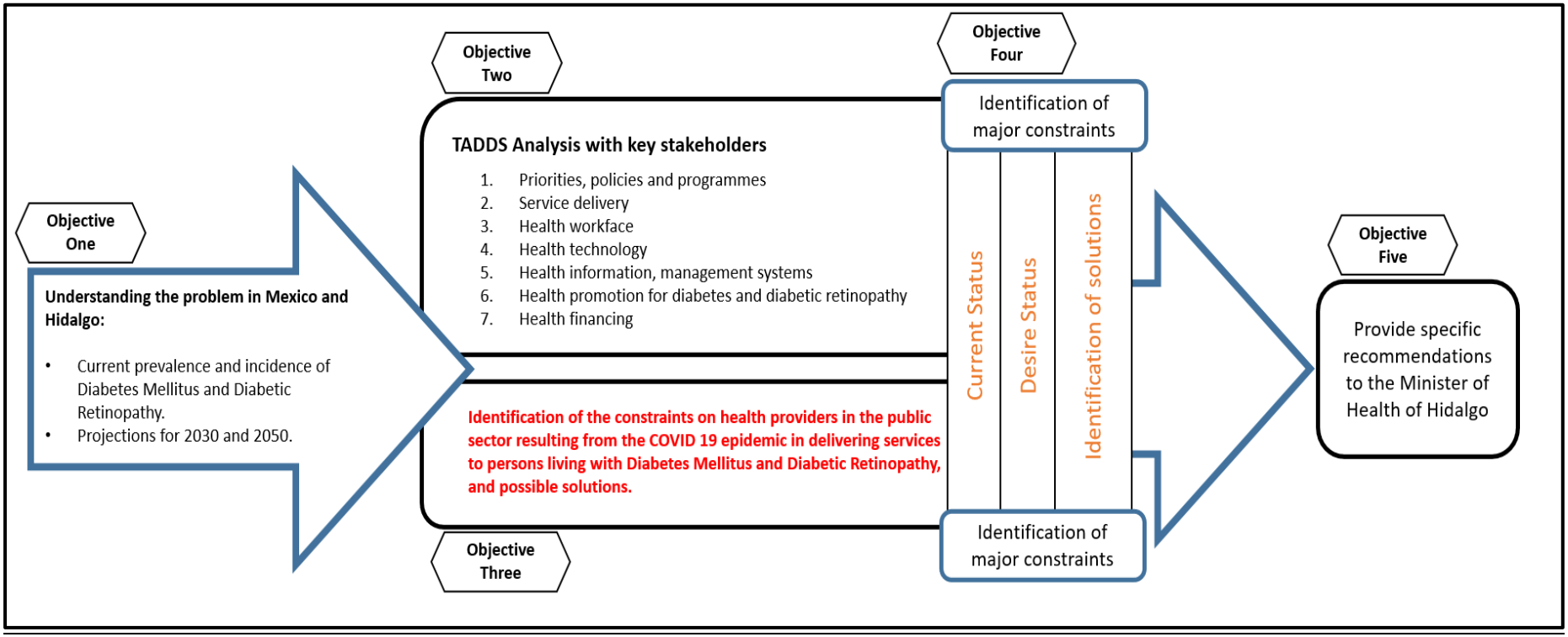
2.3. Objectives

The objectives considered for this project are:

1. To estimate from the literature, the current and future magnitude of DM and DR in Mexico and Hidalgo.
2. To assess the public health system in Hidalgo for DM and DR service provision using the “Tool for the assessment of diabetic retinopathy and diabetes management systems” (TADDS) of the World Health Organization.
3. To identify, in Hidalgo, the constraints on health providers in the public sector resulting from the COVID 19 epidemic in delivering services to persons living with DM and DR, and possible solutions.
4. To identify the major constraints to improve the eye care services for persons with DM and DR in Hidalgo.
5. To provide recommendations to the Minister of Health in Hidalgo to improve services for persons with DM and DR.

Each of the objectives is mapped in the following framework:

Figure 8. Framework of the Study



2.4. Methodology

2.4.1. Epistemological approach

Scientific research is an organised and systematic process that aims to seek solutions to specific problems based on assumptions developed from the interpretation of reality.[101]

From the perspective of the philosophy of science, different paradigms seek to understand how the world is understood. These paradigms guide and give structure to the way in which the answer to a research question is sought.[102] Some of these paradigms are:

- Positivism: It proposes that there is only one truth that can be measured through valid and reliable tools. This paradigm uses a deductive research approach by following quantitative research strategies.[103,104]
- Constructivism: It proposes that reality is constructed by the individual; therefore, it needs to be interpreted. This paradigm uses an inductive research approach by following qualitative research strategies.[104,105]
- Pragmatism: It proposes that reality is constantly reinterpreted; therefore, it uses the best methodology to reach the desired explanation. This paradigm uses inductive and deductive research approaches by following mixed research strategies.[104]

This work mainly uses constructivism. This paradigm allows the exploration of the meaning of a phenomenon using different methodologies such as case-studies, observations, life histories, narrative reviews, etc.[106,107] This paradigm differs from positivism in that the latter focuses more on explaining reality while constructivism focuses more on understanding a phenomenon or reality. [107,108]

The selection of this paradigm for this study is based on the capacity to study the way in which the different norms, guidelines, and local implementation strategies for the care of the PLWD and DR are designed and implemented from the perspective of the main stakeholders who participate in this process at the national level and in the State of Hidalgo.

In addition, these methodologies also allow exploring the perception of how the COVID-19 pandemic is affecting the provision of public health services for the PLWD.

2.4.2. Study design

This work follows a mixed-method descriptive study design, which is often used in the study of policy implementation.[109,110] It combines the strengths and limitations of qualitative and quantitative methods.[111,112] In addition, this design facilitates triangulation of the information obtained from the methodologies used in objective 2 and 3.[112]

The following sections describe the details of each methodology.

2.4.3. Study site selection justification

The author is a national and resident of Mexico, which was therefore chosen as the country of interest to analyse the national health policies and practices for DM and DR care. The thesis then explores in more detail the service implementation and constraints for DM/DR in the State of Hidalgo (located in the centre of the country) as the author knows and works in that State.

The decision to carry out the study in the State of Hidalgo are:

1) The State health authorities have a high interest in carrying out an analysis of the implementation of health care services focused on DM and DR during the COVID-19 pandemic.
2) The researcher has a professional relationship with the State authorities and their leading implementers.

2.4.4. Study participants

Sampling

This study followed a purposive sampling technique. The researcher identified the provider stakeholder groups for public policies and implementation strategies related to the care of people who live with DM and DR. Individuals from each of the stakeholder groups were then identified and approached to participate. The selection was based on the researcher's judgment and knowledge of the State and the health service to be studied.[113,114]

Stakeholder selection

In order to have the perspective of the main stakeholders from all areas related to the creation and implementation of policies and strategies for DM and DR in the public sector in Mexico and the State of Hidalgo, this study considered the participation of key informants from the following areas:

1. National health policy-makers.
2. State of Hidalgo health policy-makers.
3. State of Hidalgo health programme-implementers.
4. State of Hidalgo health care professionals offering services to people with DM and/or DR.
5. National Civil Society Organisations promoting and/or offering eye-health services to the population with DM from the State of Hidalgo and from other regions of the country.
6. National main institutions for training professionals in eye health from the State of Hidalgo and from other regions of the country.

After identifying and inviting 18 individuals representing the 6 stakeholder groups to participate in this study, 13 individuals representing all 6 stakeholders groups accepted to participate. Five invited individuals declined to participate due to their work commitments with COVID-19 at the national level and in the State of Hidalgo.

Table 11 describes the profiles of the 13 interviewees in this study. The table divides the stakeholders according to their position at national or state level.

Table 11. Profiles of participants in the study

Profile	Number of participants
NATIONAL	
• **Executive from the Department of National Epidemiology**	1
• **Director of a National Diabetes Association**	1
• **Director of the Ophthalmology Residency Programme in Mexico**	1
• **Executive from Civil Society Organisation offering eye-health services to the population with DM (Ophthalmologist)**	1
HIDALGO	
• **Executive Regional Health policy-maker (Public Health)**	1
• **Executive Regional Health policy-maker (Implementation)**	1
• **Regional coordinator of the NCDs programme**	1
• **Director of a main primary health care unit**	1
• **Director of a 2nd level referral centre**	1
• **Regional endocrinologist attending patients with DM**	1
• **Health care professionals offering services to patients with DM (Primary Care Level)**	2
• **Ophthalmologist from the Ministry of Health managing patients with DR**	1
TOTAL	13

2.5 Methodology for each Objective

2.5.1. Objective 1

This study reviews the scientific literature and documentation to estimate the current magnitude of DM and DR in Mexico and in the State of Hidalgo. In addition, the future demographic trends that are likely to affect the magnitude of DM and DR are estimated using population and disease prevalence trends.

The review of literature and documentation included:

1. **Reports from Government institutions:**

On National epidemiology of NCDs:

   a. The National Centre for Preventive Programmes and Disease Control (CENAPRECE by its acronym in Spanish).[115]
   b. National and regional reports from the National Information System on Chronic Diseases (SIC by its acronym in Spanish).[116]
   c. The National Health and Nutrition Survey (ENSANUT).[117]

On demographic data:

   d. The National Institute of Statistic and Geography (INEGI by its acronym in Spanish).[42]
   e. The National Population Council (CONAPO by its acronym in Spanish).[118]
   f. The National Council for the Evaluation of Social Development Policy (CONEVAL by its acronym in Spanish).[119]

2. **International reports / information sources used in this study:**
   a. International Diabetes Federation- Atlas 2019.[2]
   b. The Rapid Assessment of Avoidable Blindness (RAAB) Repository. [120]
   c. The DR Barometer. [121]
   d. The Global Burden of Diseases Study 2019.[122–124]
3. **Scientific articles referring to the epidemiology of DM and DR (global, regional, Mexico and Hidalgo).**

Box 1. Literature search strategy

- **Objective:** To find published scientific articles describing the prevalence of DM and DR in Mexico.
- **Database:** PubMed
- **Publication date:** 2010 to 2020.
- **Terms:** Mesh terms
- **Text availability:** Abstracts
- **Search detail**

(((("diabetes mellitus"[MeSH Terms] AND "diabetes mellitus, type 2"[MeSH Terms]) OR "diabetic retinopathy"[MeSH Terms]) AND "prevalence"[MeSH Terms] AND "mexico") AND ((y_10[Filter]) AND (fha[Filter]))

The search showed 74 potential articles to be considered in the analysis for objective 1.

With this information, the population affected by DM and DR in Mexico and Hidalgo in 2020, 2030 and 2050 was estimated.

2.5.2. Objective 2

In order to assess the provision of DM and DR services in the public health system in Hidalgo, representatives of the main stakeholders who participate in decision-making and implementation of services to manage DM and DR at the national and State level were interviewed. The Assessment of Diabetic retinopathy and Diabetes management System (TADDS) instrument of the WHO was used to conduct the interview assessments.[125]

The TADDS instrument is available in Appendix A

TADDS Instrument

The TADDS instrument was published in 2015 by WHO with the purpose to carry out an assessment of the health system for DR and DM management systems.[126] The purpose of this instrument is to standardise the evaluation of DM and DR services between different countries, with a view to identifying constraints that need to be addressed.[125]

This instrument is a structured tool that allows a systematic evaluation of the seven building blocks of a health system using DM as the "tracking disease". The tool evaluates the elements for the prevention, early detection and timely treatment of DR.[125]

Sections in TADDS:

1. Priorities, policies, and programmes
2. Service provision
3. Human resources
4. Technological resources
5. Information management systems
6. Health promotion for DM and DR
7. Finances

The WHO suggests carrying out this evaluation at the national or regional level with the stakeholders involved in the decision-making and implementation of the prevention and management of DR.

This instrument is usually used internally by countries for the development of their comprehensive care plans for DM and DR. There are two published articles on the use of the tool, from Nepal[127] and Iran.[128] Both papers provide constructive evaluations to improve the strategies related to the care of these two pathologies.

Data Collection

The researcher sent an email invitation to the stakeholders requesting an interview. Once the invitation to participate had been accepted, the researcher shared the official Spanish version of the TADDS instrument with the participants so that they could familiarise themselves with the questions and collect any information related to the questions. If there was no response, the researcher contacted and invited participants by a phone call two weeks after the first email.

The Spanish version of the TADDS instrument was used at the moment of the interview. All participants gave signed informed consent. The researcher used his knowledge of the TADDS questionnaire to clarify any questions or concepts raised by interviewees. Although the TADDS instrument is a structured tool for collecting categorical data, the researcher's own interpretation of the interviews may have introduced an interpretative bias.

For data collection, variables of the TADDS instrument in its official Spanish version were programmed in the RedCap platform,[125] which is an electronic data capture software and a workflow methodology

to design research databases of clinical trials and translational research that allows real-time data collection,[129,130] under the licence of the London School of Hygiene and Tropical Medicine, and under credentials of the researcher. Appendix B shows the first pages of the TADDS instrument programmed in RedCap as example.

Due to the COVID-19 pandemic, all stakeholders requested to do the interviews by using a virtual call. The questions were conducted in Spanish. All information was collected in Spanish in real time in the RedCap platform. For this purpose, the Zoom Pro platform was used to conduct interviews under the licence of the London School of Hygiene and Tropical Medicine, and under credentials of the researcher.[131] For quality purposes, the sessions were also recorded with consent from the interviewees. The files of the recordings were stored in the password protected researcher's computer in a folder entitled “Audios for Objective 2” during the time of the study.

For analysis purposes, and to de-identify the information collected from the interviews for objective 2 and objective 3, each interviewee was assigned a unique identification number only known by the researcher. The identification number was created with the code TADSS- followed by a consecutive number according to the order in which the interviews were conducted. Under this criterion, the first interviewee received the code TADDS001, and so on.

The software Microsoft Excel 365 were used for quantitative analysis. Descriptive analysis and contingency tables were constructed of the frequencies and proportions of the variables of interest for analysis.

2.5.3. Objective 3

This objective aimed to identify the constraints resulting from the COVID 19 epidemic on health providers in the public sector in Hidalgo state in delivering services to persons living with DM and DR, and the possible solutions.

In order to document the impact of the COVID-19 pandemic on the provision of services to people with DM, first a quantitative analysis was undertaken of:

1. Number of new cases and deaths from COVID-19 in Mexico and Hidalgo during the months of the pandemic.
2. Number of consultations to treat NCDs by public health centres in Hidalgo during the months of the pandemic.
3. Number of consultations for patients with DM by public health centres in Mexico and Hidalgo during the same period.
4. Number of ophthalmological consultations offered by public health centres in Hidalgo during the same period.

The second part of this objective was qualitative and for this purpose, a set of questions were prepared to be answered by the same representatives of stakeholders as described in objective 2. The questions were asked at the end of the collection of information required by the TADDS instrument.

Box 2. Questions designed for Objective 3

Section 1: Questions to identify the constraints on health providers in delivering services to people living with Diabetes (PLWD) due to the COVID-19 pandemic.

1. How do you think COVID-19 has impacted the **delivery of public health care services** for PLWD?
2. How do you think COVID-19 has impacted the **availability of medicines** for PLWD?
3. How do you think COVID-19 has impacted the **availability of human resources** for services for PLWD?
4. How do you think COVID-19 has impacted the **financing of services** for PLWD?

Section 2: Questions aimed to identify possible solutions.

1. What do you think are the three most important things that need to happen in the future to provide services for PLWD after COVID-19? Why do you choose these?
2. What do you think are the three most important things that need to happen in the future to provide eye health services for people living with Diabetes after COVID-19? Why do you choose these?

Qualitative methodology

Qualitative research proposes different methodologies which vary based on the interpretation of the nature of a phenomenon, however all of them focus on seeking the understanding of the perspective or experience of a person on the meaning of a phenomenon.[108]

Objective 3 looked at the perception of the main stakeholders involved in the creation of policies, strategies, and implementation of health services for people living with Diabetes including eye health services and how the COVID-19 pandemic is affecting the provision of these services.

Data was collected to understand the constraints on health providers to deliver services due to the COVID-19 pandemic, followed by the identification of possible solutions to improve the service provision of DM and DR services.

This study used the thematic analysis method for the qualitative component of the study, which allows the information provided by the interviewees to be grouped into different categories, facilitating an understanding of the subject of interest.[132] Nowell and colleagues describe a six-step process to conduct thematic analysis. [133]

1. Familiarising with data
2. Generating initial codes
3. Searching for themes
4. Reviewing themes
5. Defining and naming themes
6. Producing the report.

Advantages of thematic analysis method:

1. It is a flexible methodology that can be modified or adapted according to the research objectives or concepts of interest.[134]
2. It emphasises the importance of the experience of respondents to nature or social process. [135]
3. Its application is simple and does not require advanced theoretical or technological knowledge.[135]

4. It allows evaluating the perspectives of different participants' profiles to identify concordances and differences concerning different topics or concepts of interest.[135]
5. It personalises the concepts identified in a way that their understanding is more precise and more meaningful for readers. This process facilitates its interpretation for the creation of new actions or policies in health.[134]
6. It allows organising the information collected so as to summarise conclusions of relevance to a topic or research question.[135]

The disadvantage of thematic analysis

The flexibility of thematic analysis allows the researcher to take advantage of the richness of the information and create themes in a number of ways. However, because of this flexibility, it is necessary to report clearly, explicitly and with arguments the decisions that lead to the choice of a particular information analysis strategy, in order to ensure its methodological rigour.[133,136]

Qualitative data collection and analysis

This part of the project was conducted following the collection of information for objective two, and it was also recorded with consent from the interviewees in a different audio file in order to separate the information used for objective two and objective three.

The files of the recordings were saved in the password protected researcher's computer in a folder entitled "Audios for objective 3"). The audio file in *m4a* format of each of the Zoom Pro recordings was used to transcribe the interview. The transcription of the interview was carried out in Spanish by the researcher with the software TRANSCRIBE.[137] The Spanish version of the transcript of each participants interview was organised on Nvivo12 following the same study code given in objective 2 (TADSS001, and so on..).[138] Each transcription was saved in a Word document with the study code. All files were stored on One Drive under the Licence of the London School of Hygiene and Tropical Medicine and the credentials of the researcher. The qualitative data analysis was done with the software NVivo (QSR International Pty Ltd. Version 12) under the Licence of the London School of Hygiene and Tropical Medicine and the credentials of the researcher.[139]

The thematic analysis was carried out in Spanish because the information comes from interviews conducted in Spanish, with Spanish speakers, by a Spanish speaking researcher. Using Spanish assisted in ensuring that all the sense of the information collected was considered during the complete analysis process.

For the thematic coding of each interview, an initial coding scheme was developed according to the questions given in Box 2.

New codes were created inductively based on the responses of each interviewee and the researcher's experience in the health system of Mexico .[140] The different codes were organised into nodes, (nodes are containers of any kind of information in NVIVO such as codes, references, images, etc),[141] according to each question and topic of interest. As new codes were identified, the creation of new nodes was available. Using this process, it was possible to ensure that divergent information was not lost during the analysis process.

Before final analysis, an intentional search was done for shared common concepts to merge and reorganise the codes.[108]

Quality indicators of rigor are detailed on section 2.8 "Quality: transparency, validity, and reliability".

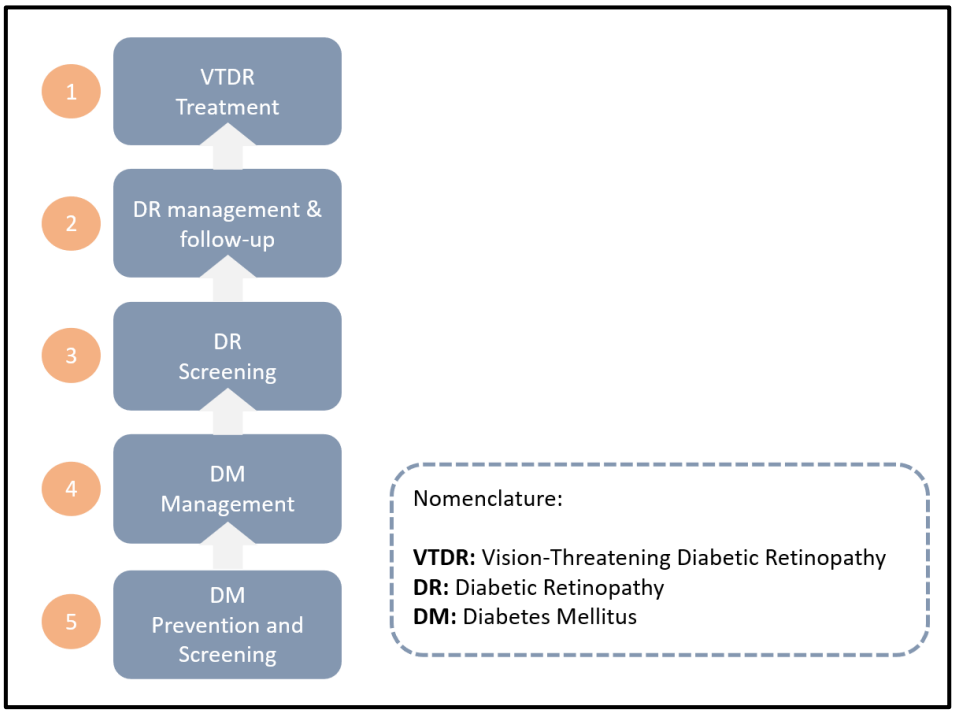
Finally, at the end of analysis, all nodes were translated from Spanish into English and verified by the researcher. The quotes from the interviews used in the following sections of this work are in English

based on the researcher's own translation and verification of the content; therefore, the researcher's own interpretation of the interviews may introduce an interpretation bias.

2.5.4. Objective 4

Following the study framework (Figure 8), objective 4 aimed to identify the major constraints to improve the services for people with DM and DR in Hidalgo, based on the findings from objectives one, two and three. An analysis was undertaken to compare the current status of services with what is required. This analysis allowed the identification of areas for improvement in prevention, early identification and management of DM and DR, including those constraints arising from the COVID-19 pandemic as identified in objective 3. The analysis used for this objective considered the continuum of care as shown in Figure 9 for DM as this is important for the prevention of DR and other DM complications.

Figure 9. Continuum of Care for Diabetic Retinopathy



The information obtained from the analysis of objectives one, two and three was used to develop a matrix which addresses:

1) the current status considering the constraints from the Covid-19 Pandemic,

2) the desired status, and

3) the identification of solutions for each of the five elements of the continuum of care for DM and DR considered for this work.

Table 12. Summary Matrix for the identification of solutions for each care stage in the continuum of care for DR

Continuum of Care Stage	Current Status considering the constraints from the Covid-19 Pandemic	Desired status	Identification of solutions
1) DM Prevention			
2) DM Management			
3) DR Screening			
4) DR Management and follow-up			
5) VTDR Treatment			

Abbreviations: DM: Diabetes Mellitus; DR: Diabetic Retinopathy; VTDR: Vision-threatening Diabetic Retinopathy

2.5.5. Objective 5

Based on the findings of Objective 4, this section developed specific recommendations for the key stakeholders which are included in the Conclusion section.

2.6. Data storage

Based on the recommendations of the Good Research Practice Report 2019-2021 of LSHTM,[142] all digital data from the quantitative analysis (Objective 2) was stored on RedCap. All digital data from the qualitative analysis (Objective 3) was stored on Nvivo 12. During the time of the project all the information was stored on OneDrive of the London School of Hygiene and Tropical Medicine under the researcher's credentials.

After the end of the project, all quantitative information from RedCap will be de-identified and saved in *cvs* files. All qualitative information from NVivo 12 will be de-identified and saved in *nvp* files. Both types of files will be kept for ten years in password protected files in the LSHTM Secure Server under the credentials of one supervisor and in a portable storage device used for this exclusive purpose and saved by the researcher.

2.7. Ethical considerations

This study was submitted for consideration by the research ethics committees of the London School of Hygiene and Tropical Medicine and the bioethics and research committee of the health services of the State of Hidalgo.

Prior to application to the ethics committees, the researcher successfully completed (August 9, 2020) the mandatory course "Research Ethics" with a score of 95% in the e-learning platform of the university (Appendix C).

The approval of the research protocol by the bioethics and research committee of the health services of the State of Hidalgo was received on August 18, 2020, under the reference: FSSA2020092 (Appendix D).

The approval of the research protocol by the research ethics committees of the London School of Hygiene and Tropical Medicine was received on October 10, 2020, under the reference: 22481 (Appendix E)

All interviewees received an information sheet about the study, had the study purpose and process explained verbally, and had their questions answered before signing an informed consent (Appendix F).

2.8. Quality: transparency, validity, and reliability

There are different ways to increase the quality and rigor of an analysis based on the methodologies used.[108]

When undertaking qualitative research, it is essential for the researcher to be aware of his own position and reflect upon it. The concern of the researcher being either an outsider or an insider to the group studied is an important one that has received increasing exploration by social scientists.[143] Insiders have easy access to data due to their knowledge of the organisation. However, they tend to be biased. Whereas, outsiders lack the knowledge, but have the advantage of curiosity.[144] The researcher should apply strategies such as *triangulation* and *reflexivity* to minimise personal bias in data collection, analysis and interpretation.[145] These techniques help ensure validity and reliability of findings.

Transparency

The COVID-19 pandemic restricted the possibility of conducting patient survey data collection from the TADDS instrument and qualitative interviews about DM and DR services. Also, the pandemic is having an important impact on the provision of routine services for DM. The study objectives and methodology were therefore adapted considering the pandemic (objective 3) to concentrate on the perceptions of providers of DM and DR services and how COVID was impacting them, and what could be done to improve the provision of care.

Validity

With respect to maximising the validity of the information obtained:

Objective 1 considered only reports from national and international institutions, and only peer-reviewed articles of the global, regional, and local burden of DM and DR disease.

For objective 2, this work uses the TADDS instrument which has been validated by the WHO. In addition, the regulations and updated guidelines established for Mexico for the care of DM and DR were monitored and this information was considered with the responses obtained in the implementation of the TADDS instrument. The same value is given to the response of each respondent based on a quantitative analysis of descriptive statistics available in the results section.

For objective 3, this work proposed six open questions to explore the effect of the COVID-19 pandemic in the provision of DM and DR services. The researcher confirmed with the interviewee the clarity of each question in order to ensure credibility when collecting an answer. In addition, this work uses triangulation when analysing the information obtained from the different sources to better understand the responses provided by all the stakeholders.[146]

Finally, this work considers the opinions of stakeholders with different profiles and their role and responsibility in the continuum of care of PLWD and DR. This includes the creation of public policies as well as local implementation of services. In the discussion, the author attempts to interpret the information obtained with an awareness of the social context and how this shapes the data collected for this work.[108]

Reliability

The work was carried out by a single researcher who has his own knowledge, experience and therefore bias. This experience and bias of the researcher has the ability to influence how a question is understood by an interviewed stakeholder. With this awareness the researcher attempted to collect

the information without influencing the interviewee to take any position or to offer specific information or guidance when applying the TADDS questionnaire and questions about COVID-19 for Objective 3.[108]

3. Results

3.1. Objective 1

To estimate from the literature, the current and future magnitude of DM and DR in Mexico and the State of Hidalgo.

3.1.1. Sources of Data

A review of reports from government institutions, international reports, and 74 peer-reviewed articles was undertaken. The list of reviewed documents and the scientific literature search strategy are described in section 2.5.1. The final sources of information used are cited.

This section considers the following:

a. Adult population projections for Mexico and Hidalgo
b. Prevalence of DM projections in the adult population
c. Proportion of PLWD having DR and VTDR
d. Estimation of the DALYs due to Severe Visual Impairment from DR

3.1.2 Population Projections

To estimate the magnitude of DM and DR for 2020, and projected magnitude for 2030 and 2050, this work considered the population aged 20 years and over for Mexico and the State of Hidalgo. In Mexico the population aged 20 years and over is approximately 83 million in 2020 and expected to increase by 14% to 95 million by 2030 and by 34% to 112 million by 2050.[147, 148] For the State of Hidalgo it is 2.015 million in 2020 and expected to increase by 15% to 2.326 million in 2030 and by 40% to 2.839 million by 2050. Table 13.

Table 13. Population aged 20 years and over in Mexico and Hidalgo for 2020, and projected to 2030 and 2050

Year	Population aged 20 yrs and over in Mexico	Population aged 20 yrs and over in Hidalgo
2020	83 178 425[a]	2,015,711[a]
2030	95,573,277[b]	2,326,456[b]
2050	111,952,062[b]	2,839,984[b]

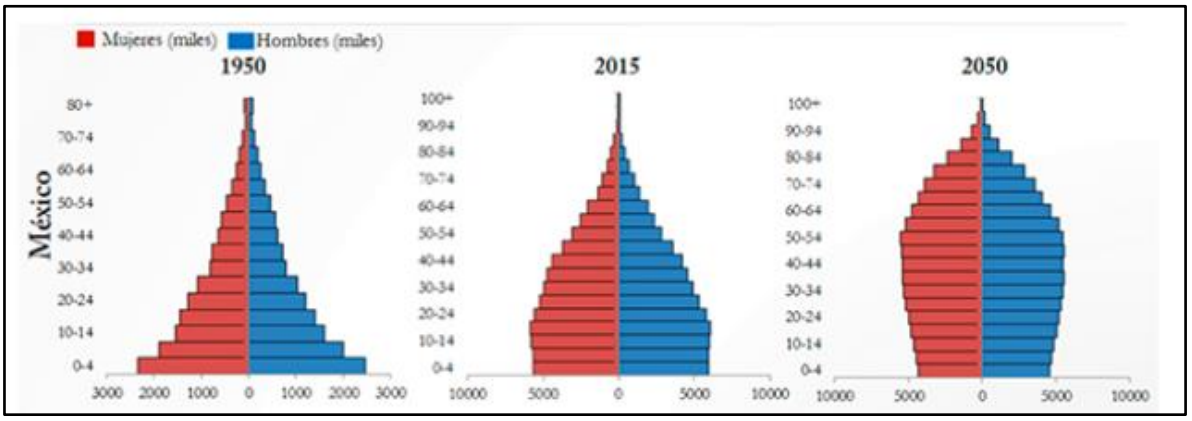
a) *National Institute of Statistics and Geography (INEGI).*[147]
b) *Projections of the National Population Council (CONAPO).* [148]

Figure 10 shows the demographic transition in Mexico between 1950, 2015 and 2050, showing an increase of the older population,[149] which is the age group particularly affected by NCDs such as DM and its associated complications.

In 1950, the population of Mexico was 25.8 million with an average life expectancy of 47 years. The population over 20 years of age was 12.4 million, being 48% of the total population.[150,151] By 2015, Mexico's population had increased to 119 million with an average life expectancy of 74 years. The population over 20 years of age was 76 million, representing 63% of the total population.[152]

Based on projections by the National Population Council (CONAPO), it is estimated that there will be 148 million people in 2050, with an average life expectancy of 80 years.[150, 148] The population over 20 years of age will be 112 million, representing 75% of the total population.

Figure 10. Demographic transition in Mexico 1950, 2015, 2050



Females in red; Males in blue. Retrieved from CONAPO [153]

Prevalence of Diabetes Mellitus

The 2019 the Diabetes Atlas (published by the IDF) reports a prevalence of DM in the Mexican population aged 20-79 years of 13.5%.[2] This prevalence is higher than the prevalence reported in 2010 (10.8%), and it is estimated that it will increase to 14.8% in 2030 and 15.4% in 2045.

Proportion of DM having DR and VTDR

To estimate the number of people having DR and VTDR (Macula Oedema and / or Proliferative DR) we used evidence from the systematic review by Teo published in 2021 applied to the number of PLWD in Mexico.[32]

Estimating DALYs

To estimate the number of DALYs attributed to severe visual impairment from DR, the 2019 Global Burden of Disease study was used and applied to the population of PLWD in Mexico.[122]

3.1.3. Estimations for Mexico

This analysis estimates that the number of people living with DM in Mexico will increase by 25% from 11.23 million in 2020 to 14.14 million in 2030 and by 53% to 17.24 million in 2050 (Table 14).

Using the reported literature estimate that approximately 33% of PLWD having DR,[32] it is estimated that the number of people in Mexico with DR will increase from 3.74 million in 2020 to 4.71 million in 2030 and 5.74 million in 2050. Similarly using from the literature that approximately 7.8% of PLWD have vision threatening DR requiring urgent treatment, [32] the number of PLWD who have VTDR in Mexico is estimated to increase from 0.87 million in 2020 to 1.12 million in 2030 and 1.34 million in 2050.

The DALYs associated with severe visual impairment due to DR in Mexico based on the Global Burden of Disease weighting are estimated to be approximately 161,000 in 2020; 203,000 in 2030; and 247,000 in 2050 (Table 14).

Table 14. Estimated magnitude of people living with DM, DR, and VTDR; and estimation of DALYs for severe visual impairment due to DR in 2020, 2030 and 2050 for Mexico

Year	Population aged 20 yrs and over	Estimated prevalence of DM in population aged 20 and over	Estimated Population with Diabetes Mellitus	Estimated number of diabetics with retinopathy (33.3%) [e]	Estimated number of diabetics with Vision Threatening (7.8) [f]	Estimation of DALYs for Severe Visual Impairment Due to Diabetic Retinopathy [g]
2020	83,178,425[a]	13.5%[c]	11,229,087	3,739,286	875,868	**161,159** (109,483 – 163,787)
2030	95,573,277[b]	14.8%[d]	14,144,845	4,710233	1,203,297	**203,006** (137,912 – 206,316)
2050	111,952,062[b]	15.4%[d]	17,240,617	5,741,125	1,344,768	**247.437** (168,096 – 251,471)

a) National Institute of Statistics and Geography (INEGI).[147]
b) Projections of the National Population Council (CONAPO). [148]
c) Prevalence of PLWD having Diabetes Mellitus in Mexico according to IDF.[2]
d) Projections of Prevalence of Diabetes Mellitus in Mexico for 2030 and 2045 according to IDF.[2]
e) Proportion of PLWD having Diabetic Retinopathy from Teo review.[32]
f) Proportion of PLWD having VTDR (Macula Oedema and/or Proliferative Diabetic Retinopathy from Teo review.[32]
g) Disease weight for severe visual impairment due to diabetic retinopathy from the 2019 Global Burden of Disease study.[122]

3.1.4. Estimations for the State of Hidalgo

When applying the estimated prevalence of DM to the population projections by CONAPO for 2030 and 2050, this analysis estimates that the number of people living with DM in Hidalgo will increase by 26% from 272,000 in 2020 to 344,000 in 2030 and by 60% to 437,000 in 2050 (Table 15).

Based on 33.3% of PLWD having DR,[32] it is estimated that the number of people with DR in Hidalgo will increase from 90,000 thousand in 2020 to 114,000 in 2030 and 145,000 thousand in 2050.

Using the reported literature estimate that approximately 7.8% of PLWD have vision threatening DR requiring urgent treatment,[32] the number of PLWD who have VTDR in Hidalgo is estimated to increase from 21,000 in 2020 to 26,000 in 2030 and 34,000 in 2050.

The DALYs associated with severe visual impairment due to DR in Mexico based on the Global Burden of Disease weighting are estimated to be approximately 4,000 in 2020, 5,000 in 2030 and 6,000 in 2050 (Table 15).

Table 15. Estimated magnitude of people living with DM, DR, and VTDR; and estimation of DALYs for severe visual impairment due to DR in 2020, 2030 and 2050 for state of Hidalgo

Year	Population aged 20 yrs and over	Estimated prevalence of DM in population aged 20 and over	Estimated Population with Diabetes Mellitus	Estimated number of diabetics with retinopathy (33.3%) [e]	Estimated number of diabetics with Vision Threatening (7.8) [f]	Estimation of DALYs for Severe Visual Impairment Due to Diabetic Retinopathy [g]
2020	2,014,000[a]	13.5%[c]	272,890	90,539	21,207	**3,902** (2,650- 3,965)
2030	2,326,456[b]	14.8%[d]	344,315	114,657	26,856	**4,941** (3,357 – 5,022)
2050	2,839,984[b]	15.4%[d]	437,357	145,640	34,113	**6,276** (4,264 – 6,379)

a) National Institute of Statistics and Geography (INEGI).[147]
b) Projections of the National Population Council (CONAPO). [148]
c) Prevalence of PLWD having Diabetes Mellitus in Mexico according to IDF.[2]
d) Projections of Prevalence of Diabetes Mellitus in Mexico for 2030 and 2045 according to IDF.[2]
e) Proportion of PLWD having Diabetic Retinopathy from Teo review.[32]
f) Proportion of PLWD having VTDR (Macula Oedema and/or Proliferative Diabetic Retinopathy from Teo review.[32]
g) Disease weight for severe visual impairment due to diabetic retinopathy from the 2019 Global Burden of Disease study.[122]

3.2. Objective 2

The public health system in Hidalgo was assessed for DM and DR service provision using the "Tool for the assessment of diabetic retinopathy and diabetes management systems" (TADDS) of the World Health Organization. [125]

Thirteen stakeholders involved in policy creation and implementation of services for DM and DR in the public sector in Mexico and the State of Hidalgo were interviewed.

Details of the respondents are given in Table 16.

Table 16. Demographic information of the 13 respondents

Categories	Number
Sex	
Male	7
Female	6
General stakeholder profile	
1. Public policy	2
2. Operative Implementer	4
3. Clinical Implementer	4
4. Civil Society (NGO)	2
5. National School Training Ophthalmologists	1
Stakeholder profile (detailed)	
NATIONAL	
National Policy Maker	1
Director of National Diabetes Association	1
Eye care NGO (Ophthalmologist)	1
Director of a National School of Ophthalmology (Ophthalmologist)	1
HIDALGO	
Regional Policy Maker	1
Regional Implementer of NCDs programmes	2
Director of DM Reference Centre	1
Director of PHC	2
Health professionals attending PLWD in PHC (Hidalgo)	1
Endocrinologist DM Reference Centre (Hidalgo)	1
Ophthalmologist attending PLWD	1

NGO: Non-Governmental Organization, **PHC:** Primary health centre, **PLWD:** People Living with Diabetes

The results of the interviews are presented in the same order as asked in the TADDS instrument.

Section 1: Priorities, policies, and programmes

This section reports the responses to national policies, programmes and guidelines related to DM and DR.

Table 17. Priorities, policies, and programmes: national programmes and guidelines

Questions	Yes (%)	No (%)	I don´t know (%)
Section: National Diabetes Plan /Programme			
1. Is diabetes listed as a national health priority?	12 (92.3 %)	1 (7.7 %)	0 (0.0%)
2. Is diabetic retinopathy (DR) listed as a priority in the national prevention of blindness plan?	8 (61.5%)	3 (23.1 %)	2 (15.4 %)
3. Does your country have a national diabetes plan?	13 (100%)	0 (0.0%)	0 (0.0%)
4. Is there a national policy on food and/or nutrition?	5 (38.5%)	3 (23.1%)	5 (38.5%)
5. Is there a national programme on food and/or nutrition?	12 (92.3 %)	0 (0.0%)	1 (7.7 %)
6. Is there a national policy on diabetes prevention?	13 (100%)	0 (0.0%)	0 (0.0%)
7. Is there a national diabetes prevention programme?	11 (84.6%)	1 (7.7 %)	1 (7.7 %)
8. Is there a national diabetes association?	12 (92.3 %)	1 (7.7 %)	0 (0.0%)
Section: Clinical Management Guidelines			
9. Are there guidelines for the management of diabetes?	12 (92.3 %)	0 (0.0%)	1 (7.7 %)
10. Is diabetic retinopathy included as a component of these guidelines?	11 (84.6%)	1 (7.7%)	1 (7.7%)
11. Are evidence-based guidelines available for the management of diabetic retinopathy?	12 (92.3 %)	0 (0.0%)	1 (7.7 %)

For the question *"Does your country have a national diabetes plan?",* all 13 respondents described that the plan covers the following four elements:

1. Primary prevention of diabetes
2. Complications (including vision impairment)
3. Community awareness and patient education
4. Clinical care, services, and supplies

Most of the respondents knew there was a National Diabetes Association, and they were asked to choose from a list the services offered by the association.

Table 18. Services of the National Diabetes Association identified by the respondents

Services	Frequency (%)
1. Primary prevention of diabetes	13 (100%)
2. Clinician education and awareness	13 (100%)
3. Policy development and advocacy	13 (100%)
4. Networks between service providers and people with diabetes	12 (92.3 %)

However, from the list described above, the Mexican Diabetes Association only offers "Clinician education and awareness", which suggests that the respondents are not familiar with the services offered.

Each of the sections of the TADDS instrument have one or two questions focused on exploring the perception of stakeholders that best represents the situation in the country between four possible options.

Regarding the national priority, policy and program for DM, the respondents were asked to choose one of the options listed in the following table, to best describe the national situation. All respondents identified DM as a national priority. In addition, 12/13 chose that the DM has plans and programmes in place for national coverage, and only 1/13 considered that those plans do not have coverage in the complete country (Table 19).

This perception concurs with the regulations and the different national guidelines and strategies described in section 1.3.3.

1. The **Official Mexican NOM [PROY-NOM-015-SSA2-2018] for the prevention, treatment and control of Diabetes mellitus.**[48]
2. The **clinical care algorithms for Type 2 Diabetes** issued by CENETEC.[49]
3. The Clinical practice guide for the diagnosis and treatment of diabetic retinopathy, issued by CENETEC in 2015.[50]
4. **The guidelines "Evidence and recommendations in diet therapy and food for patients with Diabetes mellitus",** issued by CENETEC and IMSS in 2015.[51]

Table 19. Situation reported by the respondents with respect to the priority, policies, and programmes for DM

Opinion	Frequency (%)
1) DM is not a priority; there is no national plan and no national programme.	0 (0.0%)
2) DM is listed as a priority; there is a national plan, but no programme has been implemented.	0 (0.0%)
3) DM is listed as a priority; a national plan has been formulated and a programme is in place but does not cover the whole country.	1 (7.7%)
4) DM is listed as a priority; both a plan and a programme are in place and there is national coverage.	12 (92.3%)

All respondents thought there were National Guidelines for Clinical management of DM with 6/13 stating they were not widely followed and 7/13 answering they are widely followed (Table 20). The guidelines for clinical management of DM are the ones described above.

With respect to DR, there is only one national guideline for the detection of DR at the primary level.[52] Only 2/13 respondents said that national management guidelines for DR are widely followed. And 4/13 said that the ministry of health guidelines has been formulated but health professionals are unaware of their availability and thus they are not widely used.

The guidelines for DR are not as well developed as for DM, and there is no clinical guideline about strategies to prevent, screen, diagnose or manage DR. As mentioned in the background section, the [PROY-NOM-015-SSA2-2018] on the prevention, treatment and control of DM proposes to examine all patients with DM for DR at the time of diagnosis [48], without providing details on how to do it.

Table 20. Answers of 13 respondents regarding national guidelines for Clinical Management of DM and DR

Option	Guidelines for clinical management of DM Number (%)	Guidelines for clinical management of DR Number (%)
1) There are no ministry of health-recommended guidelines.	0 (0.0%)	0 (0.0%)
2) Ministry of health guidelines have been formulated but health professionals are unaware of their availability and thus they are not widely used.	0 (0.0%)	7 (53.8%)
3) Ministry of health guidelines are available and known to the appropriate audience, but they are not widely followed.	6 (46.2%)	4 (30.8%)
4) Ministry of health guidelines have been formulated and are commonly followed.	7 (53.8%)	2 (15.4%)

Section 2: Service delivery

This section reports the responses of the 13 interviewees regarding service provision for DM and for DR.

At the community level for PLWD most respondents reported that a specialist diabetes centre was available with clinical services for diagnosis and assessment as well as patient education services. (Table 21). However, most respondents said that patient education about DR was not available.

Table 21. Service delivery: Services for PLWD at the community level

Questions	Yes (%)	No (%)	I don´t know (%)
What services are available at the community level for people living with diabetes?			
1. Clinical services for patient identification and risk assessment	12 (92.3 %)	0 (0.0%)	1 (7.7 %)
2. Patient education and support services for diabetes	13 (100%)	0 (0.0%)	NA
3. Patient education and support services for diabetic retinopathy	1 (7.7 %)	12 (92.3 %)	NA
4. Is there a specialist diabetes centre?	13 (100%)	0 (0.0%)	0 (0.0%)

Table 22 describes the responses regarding Screening for DR. Interviewees were divided about PLWD being routinely referred for eye examinations. However, almost all respondents agree that asymptomatic people are not referred for screening and people with obvious symptoms of visual loss are referred.

Respondents were not sure if there was a screening programme for DR at the community level. Finally, most respondents confirm that there are non-governmental organizations (NGOs) focused on eye care for people with DM.

Table 22. Service delivery: Diabetic Retinopathy Screening

Questions	Yes (%)	No (%)	I don´t know (%)
1. Are people with diabetes routinely referred for eye examinations?	6 (46.2%)	5 (38.5%)	2 (15.4%)
2. Does this include referral of people who are asymptomatic?	1 (7.7%)	11 (84.6%)	1 (7.7%)
3. Are people referred only if they report symptoms of vision loss?	12 (92.3 %)	0 (0.0%)	1 (7.7 %)
4. Is an eye examination incorporated into the annual cycle of care for people with diabetes?	11 (84.6%)	1 (7.7%)	1 (7.7%)
5. Is there a community screening programme for diabetic retinopathy?	5 (38.5.7 %)	2 (15.4%)	6 (46.2%)
6. Is any outreach screening provided?	1 (7.7%)	2 (15.4%)	10 (76.9%)
7. Are any non-governmental organizations (NGOs) involved in the care of people with diabetes and diabetic retinopathy?	10 (76.9%)	2 (15.4%)	1 (7.7%)

Other questions related do DM services

When asked *"where patients with DM are diagnosed"* respondents stated that it was both in the public and private sectors. The same answer was given for *"Where is long-term care for PLWD provided?"* Most respondents (12/ 13) said that health centres report statistics on DM on a monthly basis through the *The National Information System on Chronic Diseases (SIC).*[116]

When asked about the main barriers to DM care, the main cause was COVID 19 (8/13); distance to care (7/13) and lack of supplies for DM care (5/13).

When asked about the proportion of patients with DM having access to specialty services, all respondents said they did not know, but felt that access was limited.

Other questions related to DR services

Most respondents (12/ 13) said that services for the detection and management of DR are not available at the community level.

When asked about screening services for DR, 5/13 said that they are carried out in health centres.

All respondents said that there was limited equipment / technology to screen and manage DR.

Regarding the "*DR detection brigades*", 10 / 13 respondents said that they are held annually on World Diabetes Day.

Most respondents 11/13 said that referral of patients from PHC for eye examination was problematic as there are no electronic medical records.

When asked about the obstacles to screening for DR the main reasons given were: limited places offering screening (8/13); no standardised programme (7/13); no retinal photography (4/13); distance to travel (4/13) insufficient trained personnel (4/13)

When asked about the availability of DM services most respondents (11/13) said it was available everywhere but did not reach everyone. However, for DR services the respondents said it was available only to some of the population and only in some places. (Table 23).

Table 23. Availability of DM and DR services

Option	DM services Frequency (%)	DR services Frequency (%)
1) **Services available in few places and to few people** (Services are not available everywhere; they can be found only in large hospitals and are accessible only to those who can pay).	0 (0.0%)	5 (51.7 %)
2) **Some services are available to part of the population** (Services are available in regional hospitals or health centres and are partly paid by the patients. Populations in rural areas cannot reach services easily; transport to the health facilities and the cost of service are the main barriers).	0 (0.0%)	8 (61.5 %)
3) **Services are available everywhere but do not reach some of the population** (Services are available in most rural and urban areas providing care at district, regional, provincial, and tertiary levels; however, costs and transport are barriers for some patients).	11 (84.6%)	0 (0.0%)
4) **Services are available everywhere for the whole population** (Services are available in all locations and costs are paid by insurance schemes, are subsidized by the state, or are available free of charge).	2 (15.4%)	0 (0.0%)

Most respondents (8/13) felt there were only a few places that offered DM and DR services in the same location (patient-centred care), (Table 24) and felt that there is no routine collaboration between DM and DR services.

Table 24. Collaboration between providers of DM and DR services

Option	Frequency (%)
1) There is no known collaboration between separate providers of care for DM and DR.	0 (0.0%)
2) Few centres provide patient-centred care.	8 (61.5%)
3) Some centres provide patient-centred care by means of collaboration between DM and DR services	4 (30.8%)
4) Most centres provide patient-centred care based on collaboration between DM and DR services.	1 (7.7 %)

Section 3: Health workforce

This section gives the respondents perceptions on the health professionals for DM and DR services and on the training opportunities for DM and DR professionals.

For the questions:

What categories of health professionals (endocrinologist; ophthalmologist; primary care physician; general, diabetes or ophthalmic-trained nurse; dietician; etc.) are available to care for people with diabetes?

All of the respondents mentioned: dietitians, primary care physicians, endocrinologists, and ophthalmologists.

What aspects of diabetes management are included in the teaching curriculum for primary health care workers (PHCW - nurses and primary care physicians)?
Overall, the respondents felt the curriculum for PHCW was appropriate. It is evident from respondents that the curriculum should address DM-related complications as well as content on early detection, monitoring and management of DR (Table 25).

Table 25. What should the Teaching curriculum for primary health care workers contain?

Option (More than one option)	Frequency (%)
Awareness of complications of diabetes – specifically, vision loss from diabetic retinopathy	13 (100%)
Health education for patients	11 (84.6%)
Need for and timing of referral for eye examination	13 (100%)
Management of diabetic retinopathy	10 (76.9%)

How is continuing medical education provided to primary health care workers?
Most respondents felt that there was a formal continuing medical education for PHCW, although workshops were rarely available (Table 26).

Table 26. Continuing medical education for Primary Health Care Workers

Option (More than one option)	Frequency (%)
Formal training by government, university, professional organizations	11 (91.7%%)
Regular informal updates	1 (8.3%)
Workshops	2 (16.7%)
Updates on guidelines	9 (75.0%)

Most respondents felt that there were inadequate training opportunities for health professionals who provide DM and DR care (Table 27).

Table 27. Responses to the training opportunities and quality for DM and DR care providers

Option	Frequency (%)
1) Largely inadequate.	8 (61.5%)
2) Few training opportunities.	4 (30.8%)
3) Training available only in large cities and hospitals.	1 (7.7%)
4) Training for DM and DR is appropriate and of good quality.	0 (0.0%)

Section 4: Health technology
This section reports the perceptions of respondents to the availability of equipment used in DM and DR service provision (Table 28).

All respondents reported that equipment for monitoring blood glucose and examining the eye were available, and also reported the availability of slit lamps and direct ophthalmoscopes.

All respondents reported that ophthalmologists could dilate the pupil. Approximately half of respondents said that optometrists could dilate the pupil, and a similar proportion said retinal imaging was available.

Table 28. Availability of equipment for DM/DR

Services Option (More than one option)	Frequency (%)
Are the following investigations/equipment available?	
a) Biochemical laboratory tests for HbA1c (glycated haemoglobin), lipids, creatinine, urinary protein	13 (100%)
b) Blood glucose meter (owned/kept by patients with diabetes or by the health service)	13 (100%)
c) Slit lamp	13 (100%)
d) Direct ophthalmoscope	13 (100%)
Are the following investigations/equipment available? Option (More than one option)	
a) Dilated eye examination by ophthalmologist	13 (100%)
b) Dilated eye examination by refractionist /optometrist	6 (46.2%)
c) Retinal imaging – mydriatic camera	7 (53.8%)
d) Retinal imaging – non-mydriatic camera	6 (46.2%)

However most (12/13) respondents said that the necessary equipment was only available in major hospitals or private clinics (Table 29).

Table 29. Situation considered by the respondents with respect to the accessibility of health technology

Option	Frequency (%)
1) Modern examination technology not available to the majority of patients.	0 (0%)
2) Modern examination technology available only in major hospitals and private clinics.	12 (92.3%)
3) Modern examination technology available in most provincial hospitals and clinics.	1 (7.7%)
4) Modern examination technology available to all patients.	0 (0%)

Section 5: Health information management systems

This section reports the perception of respondents regarding DM and DR indicators, patient education and follow-up strategies for patients. (Table 30).

All respondents said that prevalence of DM is reported, and half said that incidence was also measured. Most respondents (12/13) said that the prevalence of vision impairment is not monitored. Most respondents said that relevant information about DM and DR is recorded in their records.

Table 30. Health information management systems for DM/DR

Questions Option (More than one option)	Frequency (%)
1. What nationally agreed health population indicators of diabetes are monitored?	
a) Prevalence	13 (100%)
b) Incidence	7 (53.8%)
c) None measured	0 (0%)
2. Is prevalence of vision impairment and blindness monitored?	
a) Yes measured	1 (7.7%)
b) Not measured	12 (92.3%)
3. What information about individual patients with diabetes is recorded in their patient medical records in hospitals? Option (More than one option)	
a) Risk factors	12 (92.3%)
b) Complications – including diabetic retinopathy	13 (100%)
c) Previous eye examination for DR	13 (100%)
d) Treatments	13 (100%)
e) Follow-up	12 (92.3%)

Section 6: Health promotion for diabetes and diabetic retinopathy

This section looks at the perception of the respondents to health education and health promotion for patients with DM and DR.

All respondents reported that information about the symptoms and complications of diabetes is provided to the community and most respondents (11/13) said that the community were also informed about risk factors for DM (Table 31). However only 3 of 13 respondents said that information was given on management and where to obtain it. The major source of information was print with TV being reported by only 3of 13 respondents.

The respondents did not believe that people are told about Diabetic Associations or Diabetic Retinopathy.

Table 31. Health Promotion and Education about DM/DR

Questions Option (More than one option)	Frequency (%)
1. Is information provided to the community about diabetes?	
a) Symptoms and signs	13 (100%)
b) Risk factors	11 (84.6%)
c) Complications	13 (100%)
d) Management	3 (23.1%)
e) Where to seek help	3 (23.1%)
2. How is community education regarding diabetes delivered? Option (More than one option)	
a) Print media	9 (69.2%)
b) mHealth: text messaging using mobile phones	0 (0%)
c) Radio/television	3 (23.1%)
d) Information was not provided	1 (7.7%)
3. What is the coverage of health promotion and patient education? Option (More than one option)	
a) National	1 (7.7%)

b) Provincial		8 (61.5%)	
c) District		12 (92.3%)	
Questions	**Yes (%)**	**No (%)**	**I don´t know (%)**
4. Are people with diabetes made aware of diabetic patients' organizations?	0 (0%)	3 (23.1%)	10 (76.9%)
5. Is information provided to the community about diabetic retinopathy?	1 (7.7%)	5 (38.8%)	7 (53.8%)

There were a variety of opinions regarding the provision of information at national and provincial level (Table 32). However, none of the respondents considered that information is provided at all three levels of care with other organisations involved in the process.

Table 32. Information and education provided to patients and community

Table 32. Information and education provided to patients and community

Option	Frequency (%)
1) Little information is provided to the community and little education to patients.	3 (23.1%)
2) Information to the community is provided occasionally and only through national-level media; not all patients receive education.	5 (38.5%)
3) Information is provided at national and provincial level; most patients receive education.	5 (38.5%)
4) Information is provided to the community at all levels; all patients receive education and patients' organizations are actively involved.	0 (0%)

3.3 Objective 3

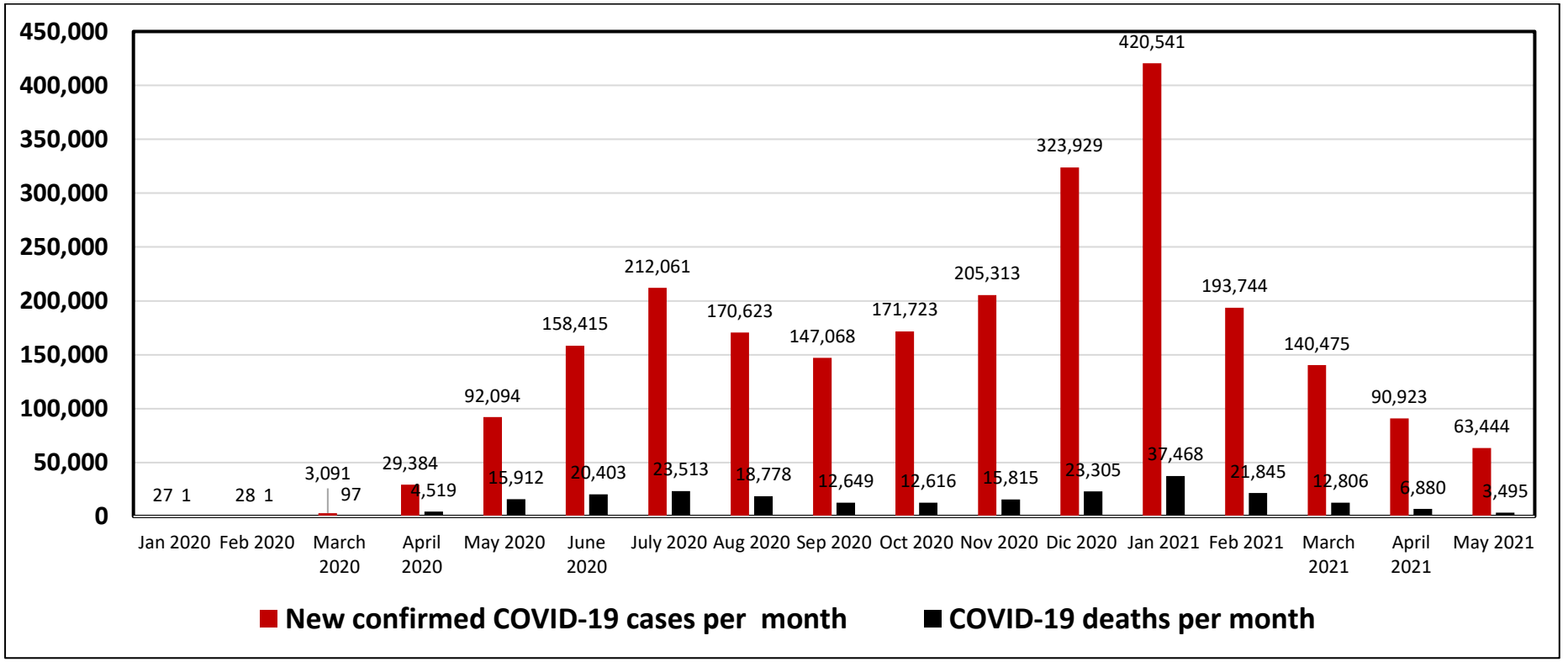
The purpose of this objective is to identify, in Hidalgo, the constraints on health providers in the public sector resulting from the COVID 19 epidemic in delivering services to persons living with DM and DR, and the possible solutions.

Part A: Analysis of data on the COVID-19 pandemic and the provision of health care for PLWD in Mexico and Hidalgo.

Figures 11 (Mexico) and 12 (Hidalgo) show the number of new monthly cases and deaths from COVID-19 reported by the Mexican authorities.

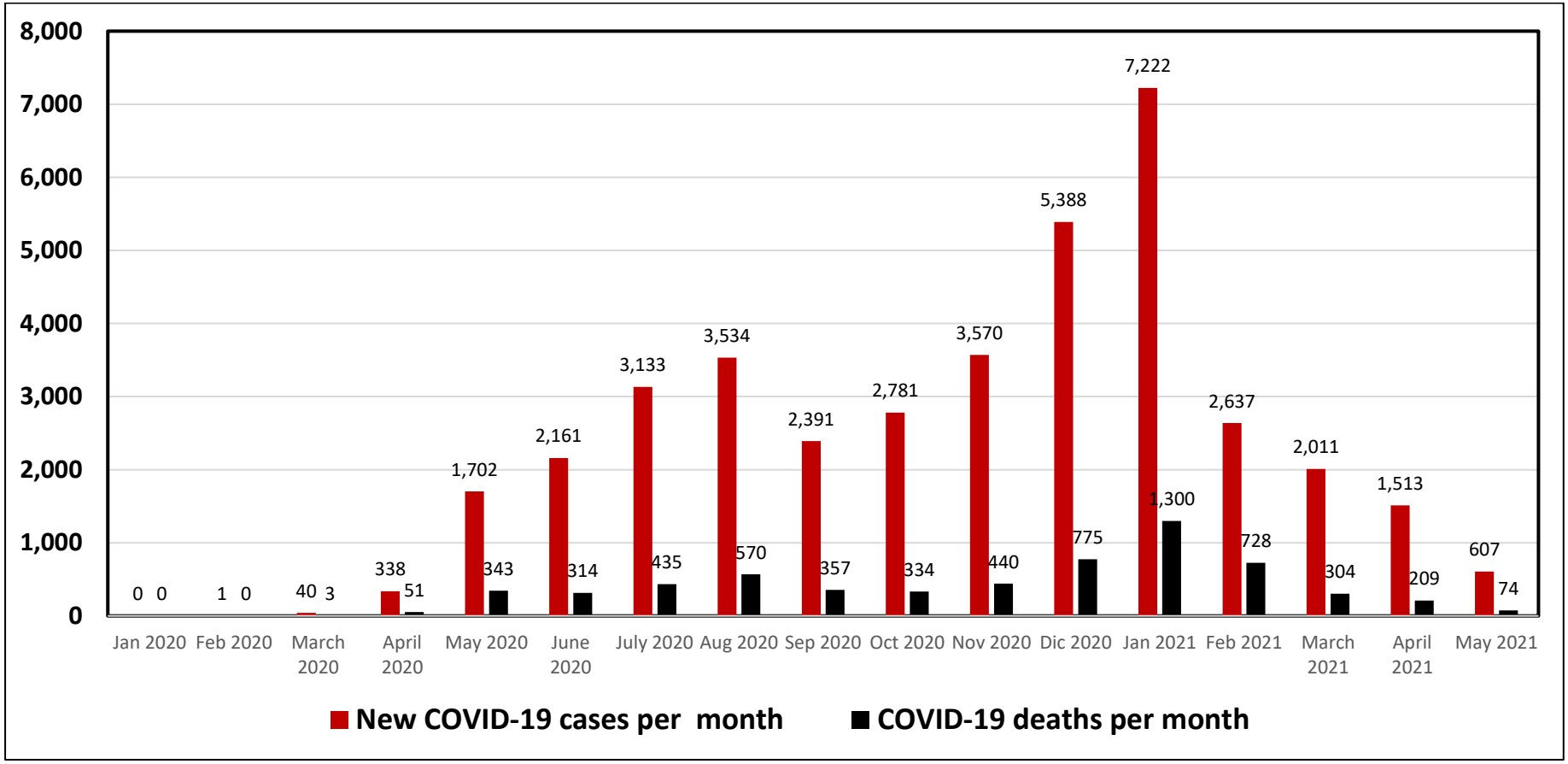
The figures show the beginning of reporting of COVID-19 cases in January 2020 at the national level and in February 2020 in the state of Hidalgo. There are two main peaks; the first occurred between the months of May and August 2020, and the second between December 2020 and January 2020. Nationally the highest number of cases and deaths from COVID-19 occurred in July 2020 and January 2021, while in Hidalgo state it was August 2020 and January 2021.

Figure 11. Monthly official reporting of COVID-19 deaths and new COVID-19 cases in Mexico



The National COVID-19 dashboard.[80]

Figure 12. Monthly official reporting of COVID-19 deaths and new COVID-19 cases in the State of Hidalgo



The National COVID-19 dashboard.[80]

Table 33 describes the number of consultations offered to patients with DM in public primary health centres at four important time points of the COVID-19 pandemic in Mexico: January (2020) considered as a pre-pandemic point, May 2020, January 2021 (peak of cases and deaths from COVID-19 in Mexico and Hidalgo) and March 2021 (when lockdown measures began to be lifted in Mexico).

When comparing the consultations registered between January 2020 and March 2021, table 33 shows that all states reported a decrease in attendance of PLWD at public health centres (range -18% to -62%). The decrease in attendance at the national level was -35%. Hidalgo reported a decrease in consultations of PLWD of -21.3%.

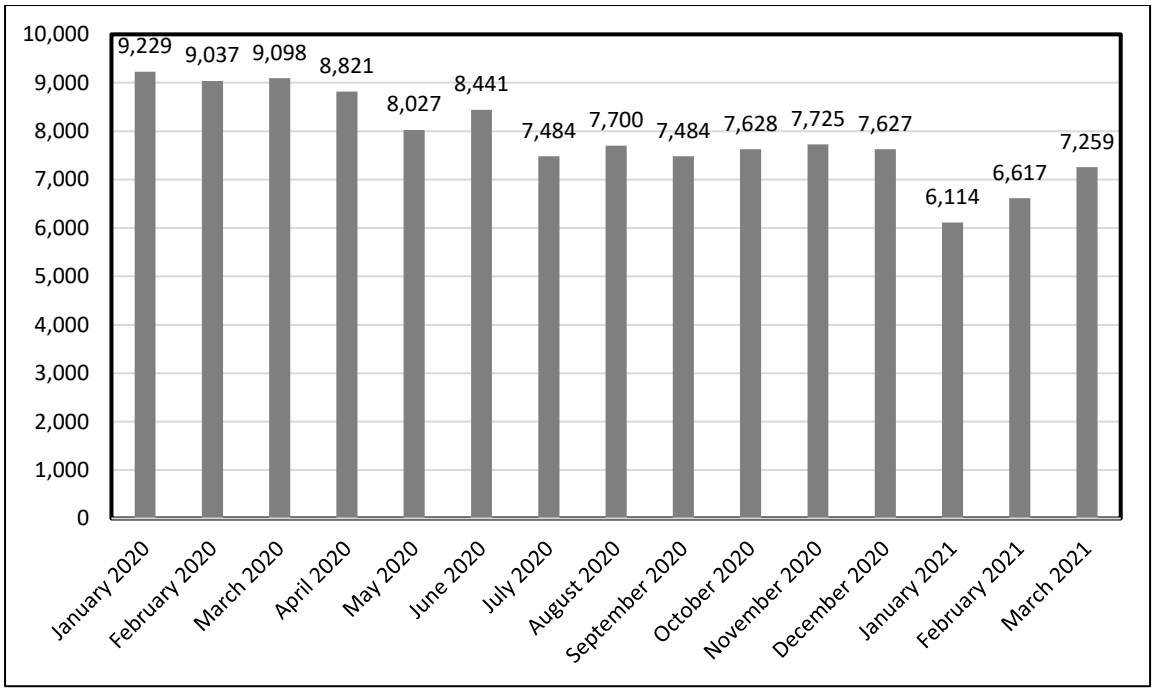
Table 33. Change in the number of consultations for PLWD at public primary health centres at four time points of the COVID-19 pandemic

#	State	January 2020 (Pre-pandemic)	May 2020 (First peak)	January 2021 (Second peak)	March 2021 (End of lockdown)	Change (%) from Jan 2020 to Mar 21
1	Aguascalientes	1,118	1,060	771	751	-32.8%
2	Baja California	866	756	438	398	-54.0%
3	Baja California Sur	510	445	373	385	-24.5%
4	Campeche	1,187	1,110	961	912	-23.2%
5	Coahuila	332	327	217	237	-28.6%
6	Colima	741	688	527	515	-30.5%
7	Chiapas	2,840	2,505	1,796	1,776	-37.5%
8	Chihuahua	3,024	2,882	1,915	1,867	-38.3%
9	Mexico City	2,754	2,577	1,598	1,510	-45.2%
10	Durango	460	408	245	292	-36.5%
11	Guanajuato	14,315	13,993	12,129	11,722	-18.1%
12	Guerrero	7,996	8,027	6,114	6,222	-22.2%
13	**Hidalgo**	**9,229**	**8,837**	**7,543**	**7,259**	**-21.3%**
14	Jalisco	6,543	6,325	4,701	4,476	-31.6%
15	Mexico (State)	11,554	11,263	8,492	8,018	-30.6%
16	Michoacán	1,924	1,322	774	715	-62.8%
17	Morelos	704	627	464	428	-39.2%
18	Nayarit	703	639	447	405	-42.4%
19	Nuevo León	1,508	1,439	1,045	993	-34.2%
20	Oaxaca	5,139	4,200	3,406	2,920	-43.2%
21	Puebla	11,713	11,123	8,778	8,044	-31.3%
22	Querétaro	5,050	4,694	3,564	3,476	-31.2%
23	Quintana Roo	2,251	2,076	1,547	1,507	-33.1%
24	San Luis Potosí	3,043	2,888	1,702	1,797	-40.9%
25	Sinaloa	1,284	1,117	765	775	-39.6%
26	Sonora	893	832	693	654	-26.8%
27	Tabasco	2,302	2,191	1,556	1,449	-37.1%
28	Tamaulipas	2,607	2,493	1,934	1,853	-28.9%
29	Tlaxcala	4,621	4,770	3,648	3,435	-25.7%
30	Veracruz	2,617	2,427	1,612	1,630	-37.7%
31	Yucatán	171	118	24	75	-56.1%
32	Zacatecas	1,826	1,811	1,340	1,391	-23.8%
TOTAL		**111,825**	**105,970**	**81,119**	**77,887**	**Mean: -34.7%**

Information obtained from public datasets: *The National Information System on Chronic Diseases,*[116] *and request to the Carlos Slim Foundation for academic purposes.*

Analysing the same source of information, figure 13 describes the number of consultations offered to patients with DM in public primary health centres in Hidalgo between January 2020 and March 2021. This figure shows a significant decrease in the number of consultations offered throughout the pandemic, identifying two downward trends in July 2020 and January 2021, which coincide with the times of greatest number of reported COVID-19 cases in Mexico.

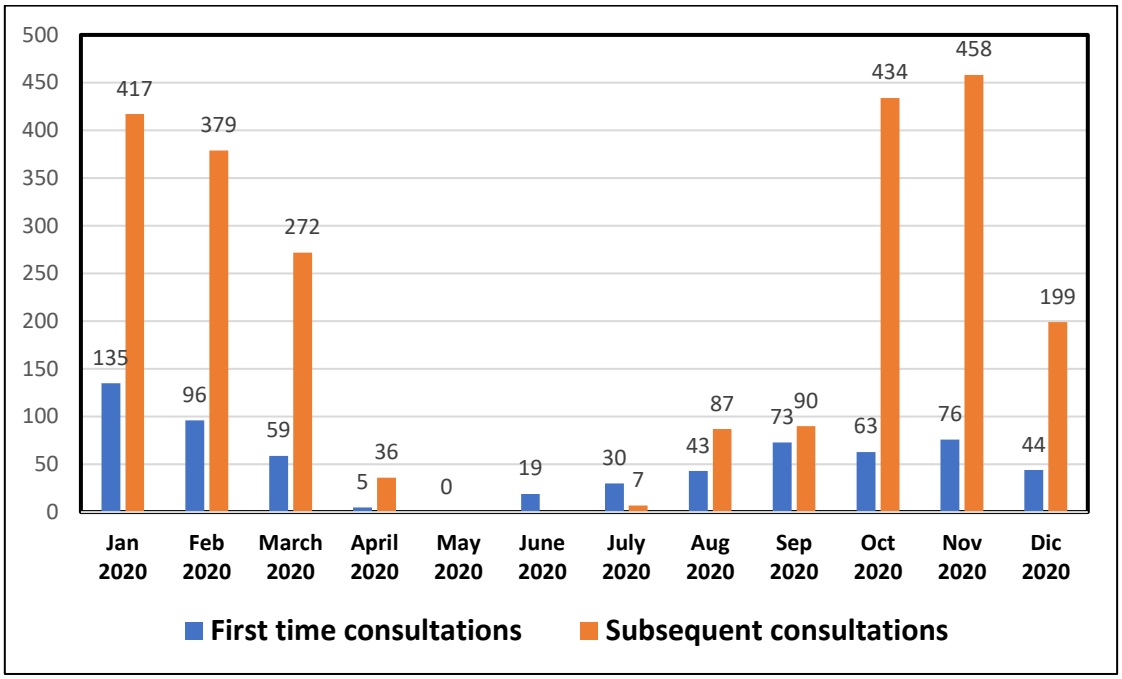
Figure 13. Change in the number of consultations of PLWD at public primary health centres in Hidalgo during the COVID-19 pandemic



Information obtained from public datasets: *The National Information System on Chronic Diseases.*[116] *and Request to the Carlos Slim Foundation for academic purposes.*

Information on the utilisation of eye health services in the public sector in Mexico and Hidalgo is limited. Figure 14 shows the number of ophthalmological consultations reported in Hidalgo by public eye health services. Although this database has incomplete data, there appears to be a decrease in attendance between April and September 2020. In October and November, services like those reported in January 2020 (pre-pandemic) were offered, however, the consultations offered in December decreased significantly again, which is consistent with the second peak of COVID-19 cases in Hidalgo. There are no data for 2021.

Figure 14. Number of ophthalmological consultations in public health services in Hidalgo in 2020



General Direction of Health Information (DGIS by its acronym in Spanish).[154]

Part B: Qualitative component

To understand the perspectives of stakeholders on how COVID impacted services for PLWD. Table 16 in section 3.2 shows the profile of the respondents.

The interviews followed the questions described in Box 1. The duration of the interviews lasted between 22 and 45 minutes, with an average of 33 minutes.

All transcripts were coded based on relevant thematic references. Then a thematic organisation and recodification of the relevant elements was undertaken. As a result of this process, 358 thematic references were identified which were divided into seven sections: six sections focused on the six questions designed for this section, and an additional section was used to identify information of relevance to the study that could not be catalogued in the six previous sections.

The following list describes the seven sections:

- Question 1: Impact of COVID-19 on the delivery of public health care services for PLWD
- Question 2: Impact of COVID-19 on the availability of medicaments for PLWD
- Question 3: Impact of COVID-19 on the availability of human resources for services for PLWD
- Question 4: Impact of COVID-19 on the financing of services for PLWD
- Question5: Important things that need to happen in the future to provide services for PLWD after COVID-19 pandemic
- Question 6: Important things that need to happen in the future to provide eye health services for people living with Diabetes after COVID-19 pandemic
- Additional elements of relevance

Quotations from the interviews are shown in *italics* enclosed in quotation marks, followed by de-identified information of the person who said the quotation, organised in parentheses in the following

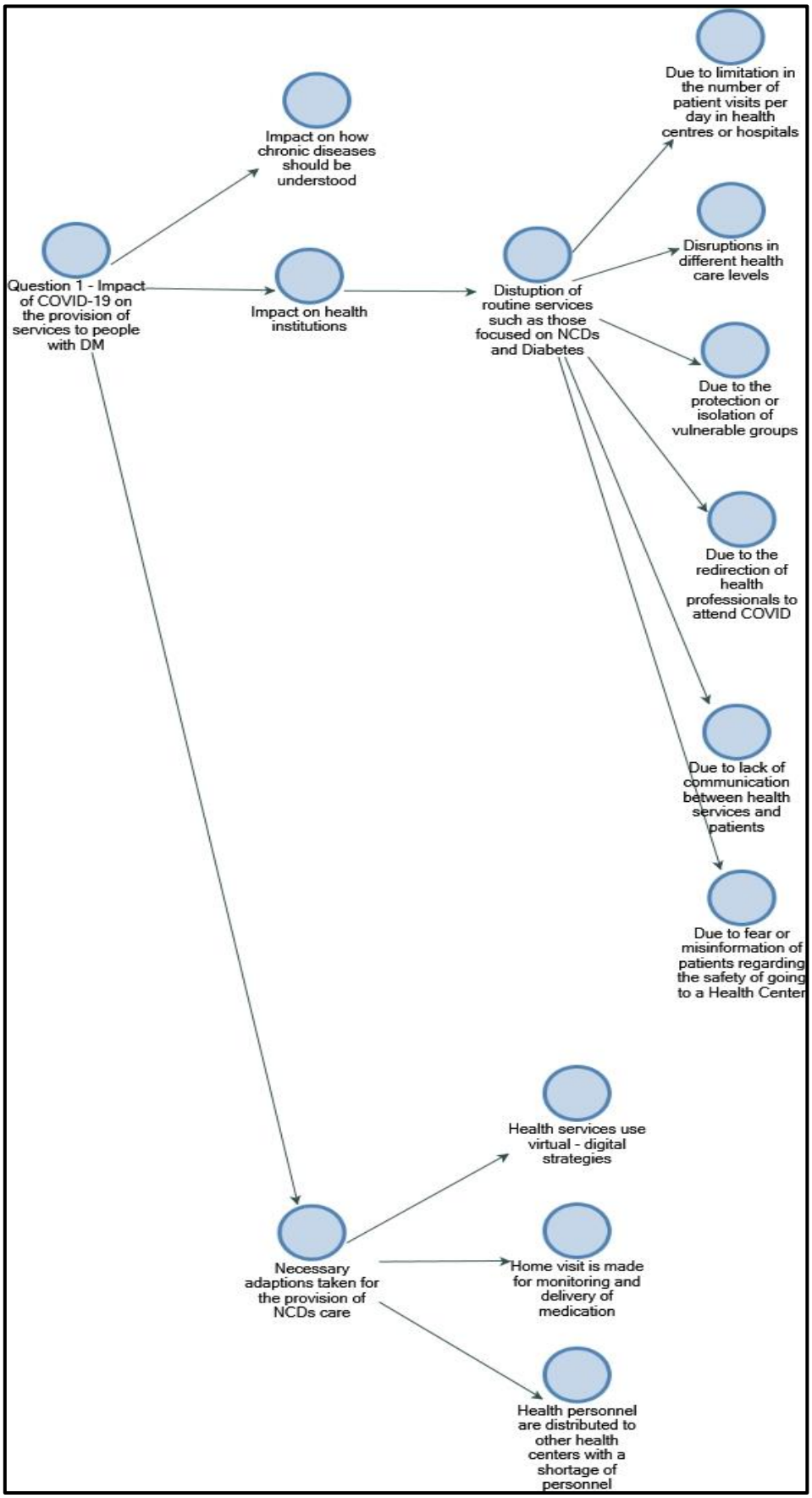
order: (study code, professional profile, sex). Quotations in this paper are in English and were translated by the researcher.

3.3.1. Analysis of "How do you think COVID-19 has impacted the delivery of public health care services for PLWD?"

The analysis for this question produced 94 codes divided into 31 nodes.

Figure 15 shows the main thematic nodes.

Figure 15. Node map for "How do you think COVID-19 has impacted the delivery of public health care services for PLWD?"



The analysis identified 3 main themes:

1) **How chronic diseases should be understood.**
2) **Impact on health institutions.**
3) **Adaptions required for the provision of NCDs care**

How chronic diseases should be understood.

The first line of thought identified that NCDs should be considered risk factors for progression or severity of COVID-19. Although interaction between different NCDs is expected to be known by health professionals, the COVID-19 pandemic has emphasised the importance of understanding these interactions as a syndemic (two or more concurrent or sequential epidemics or disease clusters in a population with biological interactions) at two levels: interaction of biosocial factors between different chronic conditions, and the interaction of biosocial factors among those with chronic conditions and COVID-19 disease.

> *"The syndemic that we currently have is diabetes, hypertension, chronic diseases, and now COVID, and it is very crucial, and it is something that has come to redesign the approaches that we may be using as a health system and with each patient".* **(TADDS002, MD, male).**

This becomes a relevant issue for Mexico due to the normalisation of suffering from NCDs such as DM and Obesity, among other chronic conditions.

> *"In Mexico, having diabetes became normal, being obese became normal […]and derived from this, it takes us in a critique situation, because although we are indeed the second place worldwide in obesity, we also have a high prevalence in cases with diabetes, and having this high prevalence, most of the population that have this disease, since it is an easy target from this new virus that has just shown us that finally they are more vulnerable than we expected."* **(TADDS002, MD, male).**

Impact on health institutions.

This is the question that most interviewees were interested to answer. When exploring the pandemic's impact on delivering public health care services for DM, the interviewees also referred to services for all NCDs since they follow the same care strategies.

The interviewees mentioned two main areas of impact:

1. Poor management by decision makers.
2. Disruption of routine services e.g. for NCDs and Diabetes.

Poor management by decision-makers.

Respondents reported poor management by decision-makers in three situations:

1. Displacement of national health priorities.
2. Lack of executive planning to address NCDs during the pandemic.
3. Failure in designing preventive strategies.

> *There has been a clear shift in the burden of care, primarily to target COVID-19. In a strategy of our country, in a strategy that has seen more to contain the pandemic in health services, without a doubt, I see a shift in national priorities, and in this case in a very important way, on diabetes care […]*
>
> *[…] COVID has impacted decision-makers from the point of view of prevention and health promotion. Since the main tools available in the Federal Government and the State governments have focused mainly on COVID, prevention and health promotion had been negatively impact, in particular with the issue of diabetes prevention and care.* **(TADDS005, MD, male)**

The authority only thinks about the moment but does not think about how we are going to start treating, or how we are going to start working on a grounded plan that allows us to really mitigate this pandemic that we have. The situation that we currently have is diabetes, hypertension, chronic diseases, and now COVID, and it is very crucial, and it is something that has come to us now to redesign the approaches that we may be operating on the patient. However, decision-makers are falling on this redesign **(TADDS002, MD, male).**

Disruption of routine services e.g. for NCDs and Diabetes.

When addressing the reasons for the disruption of different services, the analysis identified seven elements. The first discussed general disruption of services at different levels of care, and the rest identified specific reasons related to the disruption of services for patients with diabetes:

1. [General] Disruptions in different health care levels.
2. Due to limitation in the number of patient visits per day in health centres or hospitals.
3. Due to the protection or isolation of vulnerable groups.
4. Due to the redirection of health professionals to attend COVID.
5. Due to lack of communication between health services and patients.
6. Due to fear or misinformation of patients regarding the safety of visiting Health Centres.
7. Due to COVID infection of health personnel.

a. [General] Disruptions in different health care levels.

The interviewees gave different reasons for the decrease in routine services for PLWD. Some elements focus on the **supply** of these services by health institutions, and other elements related to patients **demand** for services.

The interviewees explained that due to the COVD-19 pandemic, many first and second level health services only offered services for respiratory problems and management of patients with COVID-19.

The interviewees referred to the partial or total closure of routine services for:

1. First level health care.
2. Services for the care of patients with DM.
3. Eye health services and the suspension of eye health brigades in communities surrounding urban health centres.

As a consequence of this work redistribution, some interviewees reported that services for chronic diseases in the first level health centres decreased by 60-70% compared to before the pandemic.

Regarding the partial or total closure of medical specialities for care of patients with DM

> *Many of the second-level consultations were cancelled, among them obviously the part of chronic diseases where definitely in the portfolio of services for these patients they were cancelled in our referral hospital. […]up to date, the services have not been fully opened, even at this moment our hospital is once again saturated with COVID patients, and therefore our chronic patients, especially diabetics have been left out.* **(TADDS004, MD, male).**

It is important to understand that the increase in cases due to COVID-19 saturated the first and second level health services, so that the physical spaces and health personnel for other areas of care (including eye health care) were used to care for patients with COVID.

Eye health services were affected by the lack of brigades to rural areas and the inability of the only two second-level hospitals in the State of Hidalgo with ophthalmological services to provide eye health care.

Regarding the partial or total closure of eye health services.

[…] for example, ophthalmology residents of some public institutions were sent to COVID areas, and the ophthalmology consultations were closed. […]so, these diabetic patients that we see one or twice a year constantly, their consultations were cancelled, and those ophthalmologists who were the ones who were doing the follow-up most likely were working in a COVID area. **(TADDS003, ophthalmologist, female).**

It must be considered that the eye health brigades are on pause, and the eye health reference services at the General Hospital of Pachuca and the General Hospital of Tulancingo are displaced due to the pandemic, since they are hospital attending COVID patients. **(TADDS007, MD, female).**

The next six points describe specific reasons for the disruption of services for patients with DM.

b. Due to limitation in the number of patient visits per day in health centres or hospitals.

One strategy that was implemented in health centres and medical consultation areas in second-level hospitals was to limit the number of patients attending. This decreased the flow of patients and the number of medical consultations and services offered per health professional.

The access of patients in most centres was limited. Only a certain number of patients were allowed per day. **(TADDS012, ophthalmologist, male).**

c. Due to the protection or isolation of vulnerable groups.

In order to protect people with known vulnerabilities to COVID-19 (*e.g.* over 50 years of age, people with diabetes, hypertension or obesity), the presence in health centres of these populations was discouraged. This applied to both health personnel and patients.

Vulnerable health personnel were asked to do home office work and administrative tasks. In some health centres, this strategy significantly reduced the number of health personnel working within health centres and hospitals. One strategy of the State of Hidalgo was the redistribution of health personnel without obvious vulnerabilities to other health centres that required personnel support to continue operating.

[…]in the institutions of the Ministry of Health, practically 33% of our colleagues, or our workers have any of these conditions, being carriers of diabetes, hypertension, obesity, […] our workforce was reduced by 47% when all our colleagues were sent to confinement. **(TADDS001, MD, female).**

For vulnerable patients this measure reduced the number of screenings and follow-up visits for NCDs, including DM / DR. For patients with DM under control, the health centres gave the medicaments to the patients 'relatives. Those patients with uncontrolled DM were invited to attend a consultation at the health centre by appointment; however, the interviewees said that few patients attended due to restriction of social movement during the pandemic. Instead of seeing a patient monthly, these barriers lengthened follow-up consultations to every 6 months, and some patients have never returned.

Consultations were no longer granted monthly, initially with this pandemic what we did was to give bimonthly appointments, but as time passed and the restrictions to leave, because the patients stopped going to the consultation, and many of them didn't come back until six months after the last consultation because the stay-at-home part of "stay at home" national programme. **(TADDS004, MD, male).**

d. Due to the redirection of health professionals to attend COVID.

The respondents explained that one of the strategies was the redirection of health personnel and facilities to attend to issues related to the COVID pandemic.

> *Without a doubt, today, internists, family doctors themselves, many general practitioners have been focused on the care of the pandemic, and I see that there is a lack of human resources to maintain the same level of care for diabetic patients.* **(TADDS005, MD, male).**

> *I think that both, the decrease in the number of people attending health centres and the transformation from hospitals to COVID hospitals has undoubtedly diminished their capacity to care for patients living with Diabetes in any of the services they need.* **(TADDS0012, ophthalmologist, male).**

This strategy also affected specialised personnel such as those managing eye conditions.

> *[…] in all these public hospitals, where, in general, the care was quite good and usually good, all these places were closed and were transformed in COIVD areas.* **(TADDS0003, ophthalmologist, female).**

e. Due to lack of communication between health services and patients.

Some respondents said that the strategy to be followed in a health centre was not clear and well communicated. This confusion also occurred in patients who, due to the lack of information from their physicians, did not know where or when to go to receive care.

> *I believe that patients are lost, this, many people who live with diabetes do not know and have lost their connection with their health centres, and the doctors, because they are in a very complex situation, attending COVID cares, limiting access to health centres […]* **(TADDS0006, psychologist, female).**

f. Due to fear of patients or misinformation regarding the safety of visiting Health Centres.

Some respondents attending clinics in the first and second level of care explained that the decrease in patient care in health centres or speciality services such as endocrinology or ophthalmology was due to fear on the part of patients to go to their appointments. In some cases, this fear was due to a lack of clear information because many of the care centres were physically far from COVID care areas; however, this information did not reach the patients.

> *People stopped going to the health centre due to the issue of misinformation around security protocols, and patients assumed, and still continue to assume that they are at risk of contracting COVID in a care unit, especially a public service unit, call it first level or hospital.* **(TADDS0008, MD, male).**

g. Due to COVID infection of health personnel.

Some respondents reported that the lack of medical services for diabetics was affected by infection and death of medical personnel due to COVID. This situation was seen early in the pandemic before vaccination of medical personnel.

> *On the other hand, the disease itself hit us on the issue of human resources, from the entire human side from the clinical and administrative side, more than 60% of our staff get COVID. In fact, some colleagues died.* **(TADDS0008, MD, male).**

Adaptions for the provision of NCD care

Some respondents explained the strategies taken by some health centres in Hidalgo to adapt to the challenges that the pandemic brought for the care of NCDs:

1. *Health personnel are distributed to other health centres with a shortage of personnel.*
   Because a large number of health personnel with risk factors for severe COVID were assigned to home-based work, health authorities had to redeploy active health personnel to regions where they were most needed. This situation reduced the capacity to provide routine services in primary health centres.

   > *There are also medical personnel who are adults and some of them even have chronic illnesses, but in a certain way these have been remedied because strategies have been generated to allow mobility among the same personnel from the units with a lower concentration of patients to the units with a higher concentration of patients.* **(TADDS007, MD, female).**

2. *Health services use virtual - digital strategies*
   The pandemic led to the suspension of group health services such as diabetes support groups. In order to keep in touch with patients and provide health promotion messages, some health centres used mobile phones and WhatsApp to offer remote group follow-up to diabetic patients and inform them about activities in the health centre.

   > *[…] WhatsApp is a tool that allows us to have this direct communication with users (patients), so the health centres, just as they have a census of their chronic patients, well, through this information and obviously with the consent of the people, these WhatsApp groups are created, and it is a way of providing them with information and making them aware of the actions and activities that we carry out.* **(TADDS0009, MD, male).**

3. *Home visit to monitor delivery of medication*
   Some health facilities made home visits to people with diabetes. These activities were only carried out by health centres and urban jurisdictions and depended on the availability of staff and equipment.

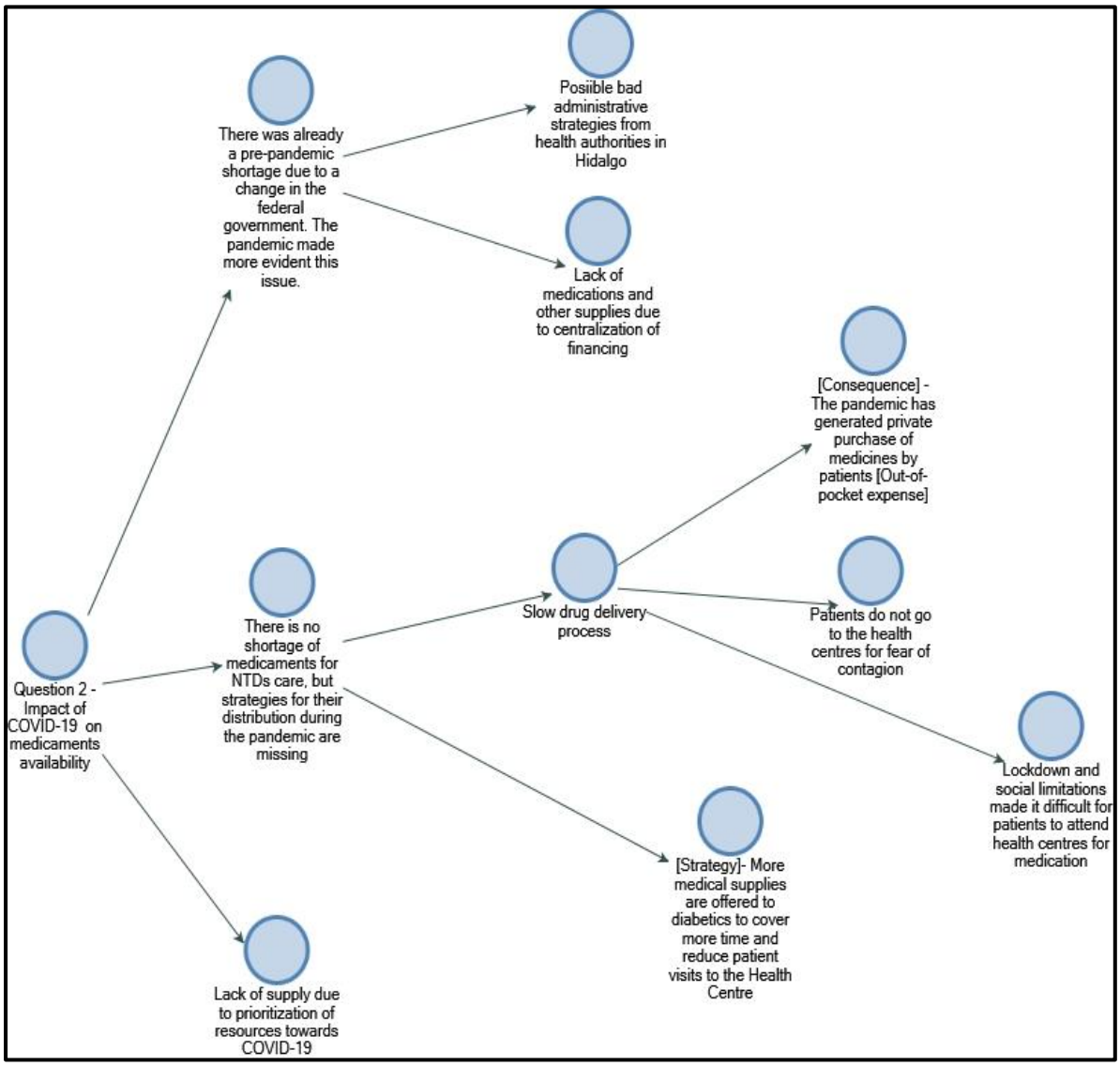
   > *We have the advantage that some health personnel go to people's homes to see the follow-up of the patients, and to see that they are in control.* **(TADDS007, MD, female).**

3.3.2. Analysis of "How do you think COVID-19 has impacted the availability of medicaments for PLWD?"

The second question looked at identifying the impact of the COVID-19 pandemic on the availability of medicaments for PLWD. This part of the analysis identified 30 codes divided into 10 nodes.

The following figure shows an organisation of the ten thematic nodes obtained from this analysis.

Figure 16. Node map resulting from the analysis of "How do you think COVID-19 has impacted the availability of medicaments for PLWD?"



The information obtained from the respondents regarding availability of medicaments was divided into three main responses:

1. There was already a pre-pandemic shortage due to a change in the federal government. The pandemic made this issue more evident.
2. There is no shortage of drugs for NCD care, but strategies for their distribution during the pandemic were missing.
3. Lack of supply of medicaments due to prioritisation of resources for COVID.

The different opinions reflect the diversity of the profiles and workplaces of the interviewees. The following sections address these perceptions.

There was already a pre-pandemic shortage due to a change in the federal government. The pandemic made this issue more evident.

Respondents described two main arguments:

1. Lack of medicaments and other supplies due to centralisation of financing
2. Bad administrative strategies from health authorities in Hidalgo

Lack of medicaments and other supplies due to centralisation of financing

The previous federal government had a decentralised national health program called *Seguro popular* (public insurance) initiated by the Secretary of Health of Mexico in 2003. It was considered the operational arm of the National System of Social Protection in Health and was executed by the National Commission for Social Protection in Health at the federal level and by the State Regimes of Social Protection in Health at the State level.[155,156] This programme allowed each State to manage different services (including the purchase of medicaments) based on their need.

Seguro Popular was replaced in 2019 by the Institute of Health for Well-being (INSABI by its acronym in Spanish), which aims to meet the same national needs, however, one of the differences is that INSABI centralises the purchase of medical supplies. This centralisation has generated a shortage of medicaments in different States at various times.[157,158]

> *[…] it has a negative effect since the disappearance of the Seguro popular and the creation of the f INSABI without new and clear operating rules, as a consequence you can see a lack of consolidated purchases that triggered an increase in out-of-pocket spending in patients, this of course, before the COVID pandemic. […]As there is no operating rule in ISANBI on the issue of drugs, diagnostic tests and services, a gap remains that negatively affects the patient.* **(TADDS0008, MD, male).**

> *The reality is different during the pandemic. We have seen it with metformin, which is the basic, and it has been scarce. This is due to what we have already been dragging, and the other that all the attention now with the pandemic to treat COVID, I do not know, I imagine that the resources, or most of the resources right now are being allocated to treat this disease.* **(TADDS0011, endocrinologist, male).**

Possible, bad administrative strategies from health authorities in Hidalgo

Although the federal government centralises the purchase and distribution of medicaments to the States, the distribution of drugs within each State depends on the State. Given this situation, it was reported by interviewees that the State of Hidalgo did not consistently adequately distribute medicaments to the different health centres, particularly during the pandemic.

> *Before the pandemic, our health centre had a supply of around 70-80% [medicaments to treat NCDs]. To begin with, I already had a negative problem in the availability of medicaments, and when COVID comes, that 70% of supply reached 46%, which is the current*

one we have […] the supply of medicaments depends on the State, I do not know if it was really the impact of COVID or it is a mismanagement of the authorities. **(TADDS0008, MD, male).**

There is no shortage of medicaments for NCD care, but strategies for their distribution during the pandemic are missing.

Some interviewees reported that there is no shortage of medicaments for NCDs. The interviewees explained the following points:

1. Slow medication use.
    a. The pandemic has generated private purchase of medicines by patients [Out-of-pocket expense]
    b. Lockdown and social limitations made it difficult for patients to attend health centres to collect medication.
    c. Patients do not go to health centres for fear of infection.
2. Extra medical supplies are offered to diabetics to cover a longer time and reduce patient visits to the Health Centre.

Slow drug delivery process

The interviewees explained that patients could not have their medical consultation and get their prescription at the same visit to the health centre. These changes occurred due to the redirection of health professionals related to the COVID-19 pandemic, and the reorganization of spaces and schedules to care for patients with DM.

There are two different moments, the part then a physician prescribes a medicament, and the part when patients get access to the prescribed medicines […] so, patients had to come at one time to have his prescription, and then at another time, so that the pharmacy would give it [the medicaments] to them. ***(TADDS0001, MD, female).***

Some respondents said that one important strategy to adapt to COVID was to give more medicaments to diabetics with good metabolic control to reduce their visits to health centres. This strategy aimed to prevent infection with COVID-19 from health centres and public transport.

What we are also doing in this effort to take care of these adults with chronic diseases, because it is to give them a supply of medicaments for a longer time, right? If we gave them for a month, well now we give them for 2, 3 or 4 months according to how they and control their condition, and that is also not there, this has helped us not to expose them more frequently, because, you know, the virus can be acquired in the health unit, but also on the way in the course of coming from your home to the health unit. **(TADDS0009, MD, male).**

The respondents reported two further important problems which reduced access to diabetes medicaments. First, the measures taken in the lockdown limited the mobility of people, and second, the fear patients had of catching COVID-19 from visiting health centres. As a consequence, many patients could not access diabetes medicaments at health centres, and instead had to buy them privately (out-of-pocket expenses).

Many of them [diabetics] did not have someone to fill their prescription, some bought them personally. **(TADDS0009, MD, male).**

Lack of supply due to prioritisation of resources towards COVID-19

Some interviewees stated that because the COVID-19 pandemic took the health system by surprise, there was a need to redirect financial resources from other health programs to address the pandemic.

Well, here we have had the situation that patients tell us: "You know, there are no medicaments, they tell me there are no medicines, I have to buy them", [...] well, we had no plans or a reserve to face this situation with the pandemic that we live, so obviously we had to prioritise in more significant resources to save the lives of patients who were presenting COVID, this somehow decreased the resources that available for chronic diseases. (**TADDS0010, nutritionist, female).**

Indeed this impact on public institutions because the orientation of the budget was towards the pandemic, diverting the coverage of resources previously established in other programs. (**TADDS0012, ophthalmologist, male).**

3.3.3. Analysis of "Impact of COVID-19 on the availability of human resources for services for PLWD?"

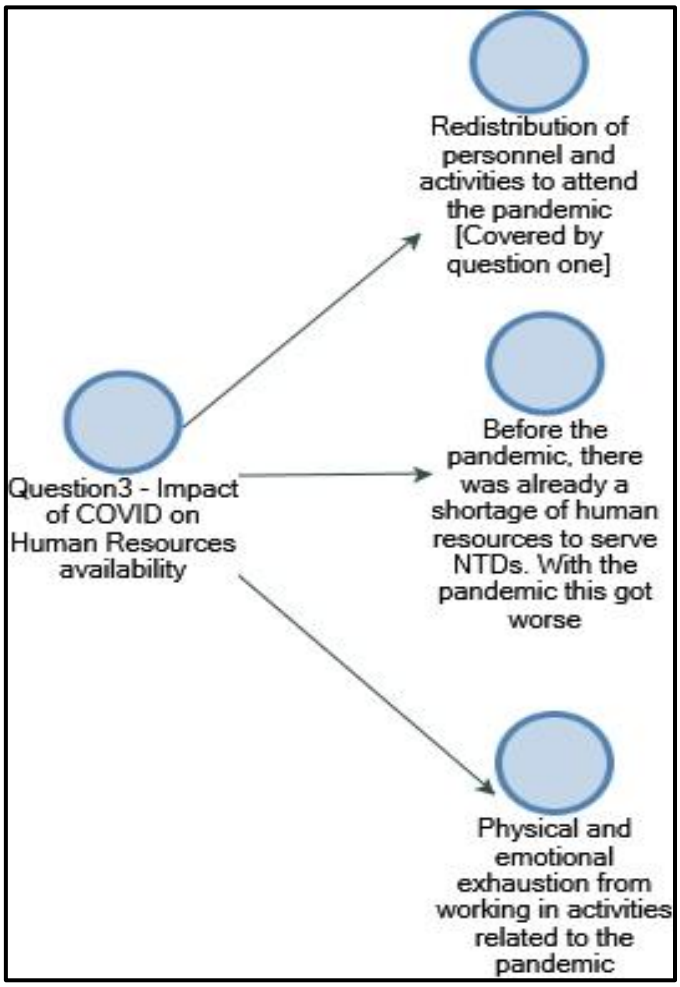
This section reports responses not already provided in question 1. This analysis identified 16 codes divided in 3 nodes.

The interviewees talked about the following points:

1. Redistribution of personnel to attend the pandemic [Covered by question one].
2. Before the pandemic, there was already a shortage of human resources to serve NCDs; the pandemic made this worse.
3. Physical and emotional exhaustion of health staff working in the pandemic.

Figure 17 shows the 3 nodes obtained from this analysis.

Figure 17. Node map resulting from the analysis of "Impact of COVID-19 on the availability of human resources for services for PLWD?"



Before the pandemic, there was already a shortage of human resources for NCDs; the pandemic made this worse.

In addition to what was already reported in question one, some respondents stated that before the pandemic there was already a deficit of health personnel for NCDs, which included services for PLWD. This situation is not homogeneous and varies between health centres and hospitals.

> *Structurally, I believe that the country has a debt in the training of human resources for the care of the diabetic patient, but especially now in the COVID pandemic, this situation is more evident. In addition, internists, endocrinologists, etc are focusing more in treating COVID than in monitoring the diabetic patient* (**TADDS005, MD, male).**
>
> *In some health centres, speaking on the first level, there was a lack of personnel to treat chronic diseases, and well, in the pandemic, this was put aside. So, as I told you in the previous question, all the resources went to COVID, and they [decision makers] did not turn to see the needs that already existed a lack of personnel. So, yes, the situation from before was aggravated* (**TADDS011, endocrinologist, male).**

Physical and emotional exhaustion of health staff working in the pandemic.
Some respondents spoke about the physical and emotional deterioration of health personnel during the pandemic.

> *I consider that at this moment our colleagues are very tired, exhausted. This, not only because the number of consultations that there are in each unit, but also because of the stress produced by feeling with this probability of being infected by COVID. So I think our colleagues who follow patients in daily care are physically and emotionally exhausted. (**TADDS004, MD, female).***

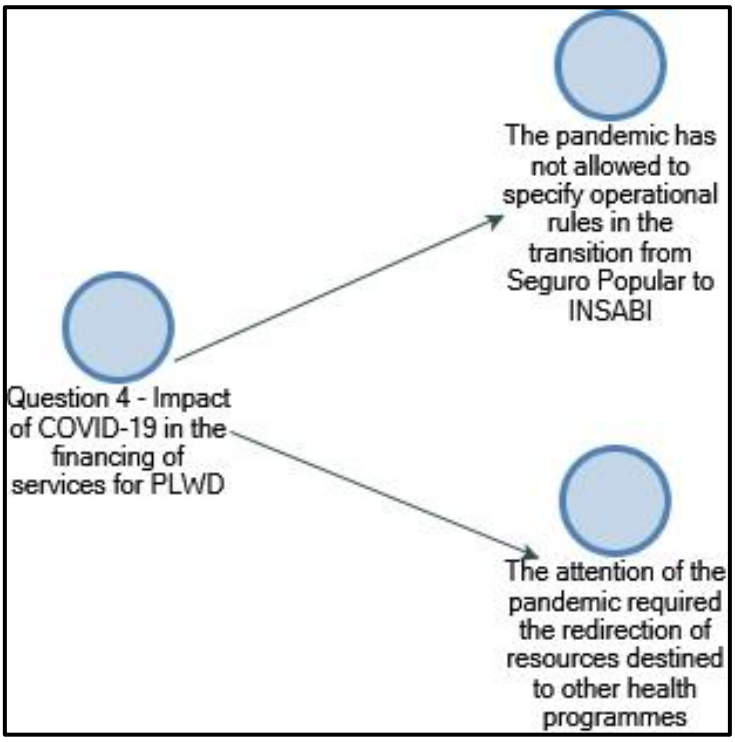
3.3.4. Analysis of "Impact of COVID-19 on the financing of services for PLWD?"

The fourth question investigated the impact of the COVID-19 pandemic on the financing of services for PLWD. This part of the analysis identified seven codes divided into two nodes:

1. The pandemic has caused problems for the transition from Seguro Popular to INSABI.
2. The pandemic resulted in the redirection of financial resources from other health programmes to COVID.

Figure 18 shows an organisation of the two thematic nodes obtained from this analysis.

Figure 18. Node map resulting from the analysis of "Impact of COVID-19 on the financing of services for PLWD?"



The pandemic has caused problems for the transition from Seguro Popular to INSABI.
As explained previously, the change of federal government resulted in a new centralised institution (INSABI) for procurement. The change requires new operational regulations, which, according to some respondents, has not occurred because federal and state decision-makers are prioritising work and resources on the pandemic.
The lack of clear operating regulations has resulted in a gap in the central purchase and distribution of resources; which for PLWD is reflected in increased out-of-pocket expenses.

> *We see a negative effect. Since the disappearance of the Seguro Popular and the creation of*

the INSABI without operating rules, it is already a matter of lack of consolidated purchases that triggered an increase in out-of-pocket spending on patients, of course, before the COVID pandemic. During the pandemic, this situation has worsened […] the Seguro Popular administered the issue of medical care, as there are no operating rules in the INSABI on the issue of drugs, diagnostic tests and services, there is a negative gap for the patient **(TADDS0008, MD, male).**

The pandemic resulted in the redirection of financial resources from other health programmes to COVID.

The respondents explained that to deal with the pandemic there was a redirection of resources from other health programmes. As mentioned previously, some of these resources are health personnel; however, the use of financial resources allocated for other programmes was reallocated for COVID care, particularly to strengthen hospital and intensive care capacities. One of the programs affected by this decision is diabetes care.

Obviously, there is an expense destined for the control of diabetes at the national and State level, but a cut had to be made, right? And then, that implied that the availability and financing of the disease decreased, in all senses, because for example, if there was availability to hire a doctor, one more nurse to care chronic patients in rural areas, well, that resource to focus on COVID **(TADDS010, nutritionist, female).**

I think there is an impact because of the pandemic. Because, finally, hospitals and health centres have established budgets, and during the pandemic much, much, much was focused on the purchase of personal bio-protection equipment, on treatments for COVID patients, on equipment, on having ventilators, and having all that equipment, and I think it was limited **(TADDS012, ophthalmologist, male).**

3.3.5. Analysis of "Important things that need to happen in the future to provide services for PLWD after COVID-19?"

Question five focused on exploring the things that need to happen in the future to provide services for PLWD after COVID-19. This part of the analysis identified 46 thematic references divided in 22 nodes organised in eight categories described in the following list:

I. Specific interventions for PLWD care

1. To ensure the continuum of care for PLWD
2. To reinforce preventive strategies and lifestyle change
3. To reinforce interventions on the patients´ mental health
4. To treat patients with DM in non-COVID areas
5. To prioritise COVID vaccination of doctors and patients with vulnerabilities such as DM
6. To ensure self-monitoring of glucose at home

II. Specific interventions for the screening of NCDs

7. To ensure NCDs and DM screenings in health centres and the community

III. Communication strategies

8. To promote patient´s confidence in visiting health centres and hospitals during the pandemic
9. To clarify the messages given to patients during the pandemic

IV. Education strategies

Focused on diabetic patients

10. To ensure patient education and empowerment strategies
11. To transfer patient education and empowerment strategies to virtual platforms.
12. To restart or redesign mutual aid groups.

Focused on health personnel

13. To strengthen Human Resources education and training for NCDs
14. To ensure training in insulin therapy in first level health centres

V. Home or community interventions

15. To restructure home visits – to bring interventions from the Health Centre to the home and the community.
16. To use portable labs and point-of-care strategies

VI. Interventions focused on supplies for DM care

17. To ensure supplies for the prevention and care of DM

VII. Human resource strategies

18. To ensure job stability for health personnel (psychologists, nutritionists, etc)
19. To ensure sufficient health personnel for DM care

VIII. Financial strategies

20. To define the INSABI service portfolio
21. To change the financing system of services for patients with DM according to the needs of Mexico
22. To ensure full funding of services for NCDs and DM

Among all the responses obtained, four topics were frequently mentioned by the respondents; three focused on educational components for patients and health personnel, and one on ensuring the necessary supplies for the prevention and management of DM.

To ensure patient education and empowerment strategies

Most of the respondents explained that it is essential to improve strategies to educate and empower patients with DM. From the experience of the respondents, the patient usually normalises his disease and his lifestyle, in such a way that when a diagnosis such as obesity or DM is received, the patient takes time to reach an acceptance process and be able to focus on learning about your illness and how to manage it.

> *I believe that patient education about their disease is essential, because many times, the patient unloads the responsibility on his doctor, so it is very easy to say, "my doctor does not control me", when in reality it is the patient who should be empowered to be able to make decisions and actions at a given moment, right? In Mexico, diseases such as obesity and diabetes are normalised in society, so what happens is that a patient takes a long time to reach an acceptance stage*. **(TADDS001, MD, female).**

To transfer patient education and empowerment strategies to virtual platforms

Before the pandemic, a patient had to visit the health centre at least once a month to access mutual aid groups or medical advice from health professionals. Some respondents suggested that one of the lessons of the COVID-19 pandemic was the need to bring educational strategies and empowerment of patients to virtual platforms (in particular, Facebook Live and Zoom) to make the opportunity to access education easier and more frequent. However, it should be acknowledged that a large percentage of patients do not have a smart cell phone or access to the internet.

To strengthen Human Resources education and training for NCDs

Some respondents said that general practitioners do not have up-to-date training. In particular, the respondents with a medical profile mentioned that it is not usual for a first-level doctor to know the insulin therapy strategies for managing patients with DM. The lack of trained personnel in this area creates a need to refer patients to second level hospitals or specialised centres, which has the consequence that a patient delays the start of insulin treatment.

> *So, what do we realise? that there is a great gap in education, not only of people living with diabetes, but also to do the daily day, but also of top-level doctors that today they do not know how to treat someone with insulin. On the other hand, doctors also normalise the presence of some diseases such as obesity, and we do not realise that it is a disease linked to*

other cardiovascular conditions. Many doctors also normalised bad eating habits […] **(TADDS0006, psychologist, female).**

Another area where much effort is needed to improve education is about disease prevention and timely detection. For example, in my experience, it is challenging to convince a doctor that prediabetes is a disease that is already beginning to have consequences in the body. **(TADDS0005, MD, male).**

To ensure supplies for DM care

Among the most common responses was the need to strengthen the supply chain for laboratories and medicines. One respondent pointed the need to identify patients with any NCD as part of a priority group due to the high prevalence of obesity and DM in Mexico, and that supplies to carry out these interventions are needed.

3.3.6. Analysis of "Important things that need to happen in the future to provide eye health services for people living with DM after COVID-19"

Question six explored the actions needed in the future to provide eye health services for PLWD after COVID-19. This part of the analysis identified 52 codes divided into 18 nodes organised in seven categories described in the following list:

I. Clinical guidelines and regulations

1. To make eye health a priority in national health strategies.
2. To improve the guidelines and policies for eye health of PLWD.

II. Strategies to improve eye health services in Hidalgo.

3. To ensure a coordinated referral system between primary health centres and eye health speciality centres.
4. To look for public-private partnerships.
5. To expand eye health services according to the needs of the State of Hidalgo.

III. Human Resources

6. To increase human resources in eye health services.
7. To strengthen the training of human resources at all levels of care for eye health.

IV. Implementation of educational strategies

For health personnel:

8. To strengthen strategies for training residents in ophthalmology.

For patients:

9. To provide education and empowerment strategies about eye health and DR.

V. Eye health screening

10. To provide eye screening in first-level health centres.
    a. To have technicians carry out eye screenings in first-level health centres.
    b. To train technicians to ensure competency of correct fundus evaluation in first-level health centres.
    c. To ensure the necessary equipment for fundus evaluation in first-level health centres
11. To consider purchasing portable eye health screening technologies.
12. To standardise or ensure brigade strategies where eye health is also addressed (Screening and Education).

VI. Eye health care from first-level health centres

13. To prioritise the prevention of DR by good control of DM.
14. To conduct an active search for known patients at high risk of visual loss.
15. To ensure that a patient with DM visits eye health services at least once a year.

16. To equip first-level health centres with mydriatic fundus cameras.
17. To consider telemedicine for the screening and timely detection of eye health problems from first-level health centres.

VII. Ophthalmology speciality service improvements

18. To avoid late scheduling of appointments in eye speciality services.

For this section four topics were frequently discussed.

To make eye health an operational priority in national health strategies

The response that was reported the most is the need to make eye health an operational national priority. For DR there is a normative framework that recommends its early detection and management; however, this is not reflected in operational guidelines. The respondents said that this situation was made worse during the pandemic because human resources for eye health were suspended or relocated to care of COVID cases, generating a noticeable interruption of eye health services. There clinical guidelines for DR care need to include screening, detection in health centres, and referral strategies to speciality centres.

> *The topic of eye health at the national and State level is a priority; however, operationally, these services have been forgotten. […] The national guidelines also need to improve their indications as they do not mention operational strategies for carrying out diabetic retinopathy screening and management strategies.* **(TADDS0007, MD, female).**

To expand the eye health services according to the needs of the State of Hidalgo

Those respondents working within the State of Hidalgo said that it is necessary to decentralise eye health care since only two second-level hospitals have eye health services, and one of them suspended its services due to its transformation into a COVID hospital. One of the strategies mentioned frequently was to expand the coverage of eye health services in the State by opening eye health units in all the three second-level hospitals in the State. In addition, use of telemedicine to conduct screening in primary health centres was recommended.

> *I believe that we would have to invest a little more in expanding this network in second-level hospitals in the State, and that telemedicine is already beginning to work in health units to detect early cases of cataract and diabetic retinopathy.* **(TADDS0009, MD, male).**

To standardise brigade strategies in which eye health for PLWD is included (Screening and Education).

Another common response for DR screening was to ensure a standardised strategy to carry out eye health brigades in the State. Before the pandemic, these brigades were carried out without much planning, and the number of brigades depended on the resources available in the health jurisdictions. During the pandemic, these brigades were suspended until further notice. The respondents propose to take this activity and standardise it in time and operation.

To consider the use of telemedicine for the screening and timely detection of eye health problems from first-level health centres

The use of telemedicine has been mentioned in different questions by the respondents. Due to the need to expand the capacity of the eye health system in the State of Hidalgo, the respondents suggested telemedicine as a resource to carry out screenings in rural areas and in health centres where there are no trained personnel to undertake fundus evaluation.

3.3.7. Additional ideas of relevance

This part of the analysis identified 20 codes divided into 9 nodes organised in three categories described in the following list:

On eye health

1. Eye health has not been a priority for the health system, and COVID has displaced eye care.
    a. Eye health is not a national operational priority.
b. Delay in Eye care: [Consequence] Poor control of visual problems (due to delay)
2. Visually impaired care is a high-risk activity during the COVID-19 pandemic.

On NCDs and DM care

3. It is necessary to understand the syndemic between NCDs and COVID-19

On negative consequences in care for PLWD due to the COVID-19 pandemic

4. Poor metabolic control of PLWD due to the pandemic
5. High out-of-pocket expenditure by patients with DM and DR (due to delay of care)
6. Increased vulnerability to COVID-19 in patients with NCDs and DM

Two topics were frequently mentioned by the respondents:

It is necessary to understand the syndemic between NCDs and COVID-19

A concept mentioned by the respondents is "Syndemic", which refers to two or more diseases that coexist in time and place with common biosocial factors. Some respondents referred to obesity, DM and COVID-19 as being syndemic. Respondents explained that it is necessary to understand that health is the result of social determinants and that risk factors and diseases are not independent. Understanding this concept will lead to better prevention and medical care.

Poor metabolic control of PLWD due to the pandemic

Another idea frequently reported was the need to resume and reform care services for NCDs after the COVID-19 pandemic. The pandemic has caused poor control of diseases, such as DM, and an increase in complications, such as DR. Some respondents said that as eye health services reopen, DR cases are being seen with a severity that could have been prevented if the patient had had good metabolic control and if their attendance at eye health centres had not been delayed.

3.4. Objective 4

To address this objective, for each of the six elements considered by the TADDS instrument an analysis was undertaken to summarise **the current status** (considering the constraints from the Covid-19 Pandemic), **the desired state**, and **the identified solutions**.

The six elements of TADDS are:

1) Priorities, policies, and programmes
2) Health promotion
3) Service provision
4) Human resources
5) Technological and Pharmacological resources
6) Information management systems

The analysis is presented in tabular form for each of the five elements in the DR continuum of care described in the figure 9:

1. DM Prevention and Screening
2. DM Management
3. DR Screening
4. DR Management & follow-up
5. VTDR Treatment and Rehabilitation

3.4.1. Prevention and Screening of DM

Table 34. Prevention and Screening of DM; current status, desired status, identified solutions

Health system block (TADDS instrument)	Current status considering the constraints from the Covid-19 Pandemic	Desired status	Identified solutions
1) Priorities, policies, and programmes	• DM is a national priority in the health system. • There are clinical standards and guidelines (section 3.3) where the strategies for preventing DM to be used at the three levels of care are described. [48, 49, 50, 51] However, these documents address prevention in a general way without specific operational strategies. • The existing clinical guidelines are updated every five years. • There are no updated guidelines for the prevention of DM during the COVID-19 pandemic, or for those patients who had COVID-19 and may develop hyperglycaemia "de novo".[159] • There are no clinical guidelines for preventing NCDs which have comorbidity with DM (e.g. obesity and hypertension).[160]	• To have guidelines for operational strategies to prevent DM for use in health centres and the community. • To develop regional (in Hidalgo) clinical algorithms for preventing DM during the COVID-19 pandemic and/or a Hub with updated guidelines and international scientific literature. • To develop strategies for the surveillance of hyperglycaemia "de novo"(also attributed to COIVD-19 disease) for Hidalgo (e.g., every two years) • To update the clinical guidelines every year. • To have integrated clinical guidelines for the **prevention**, diagnosis, treatment of NCDs including DM.	To recommend to the Federal Ministry of Health **updating the clinical guidelines** for DM prevention detection management, and the annual review of National / State clinical guidelines with experts.[161] To recommend the development of an integrated National clinical guideline for the prevention, diagnosis, treatment of NCDs including DM. This should cover the understanding and management of the syndemic between NCDS and SARS-Cov-2 infection.

2) Health promotion	• Health promotion strategies for DM are proposed and implemented at the regional level (in this case, Hidalgo). • Information on symptoms, risk factors, and complications is provided to patients with DM. • Information on services for different stages or complications of the disease is not offered systematically. • Information on prevention and complications is not systematically offered to people with pre-diabetes.	• Carry out health promotion strategies to prevent DM in the general population and especially those who attend first-level health centres. This should include information about complications and services available. • • To have health promotion strategies for people with pre-diabetes to avoid their progression to DM.	• To request health authorities to **develop health promotion strategies for DM** for those who attend health centres that includes information about complications and available DM services. • To recommend to national and regional health authorities the creation of **health promotion strategies focused on people with pre-diabetes** with the intention to prevent the progression to DM.
3) Service provision	• The screening for DM is carried out in first-level health centres using the digital tool MIDO (integrated measurement for timely detection in English)[162,163] • NCD screening decreased during the pandemic due to lack of personnel. • Though MIDO access to screening is available to the entire population; health professionals only do glucose measurements on patients and not companions.	• Screen the population that visits a health centre for DM through the MIDO strategy. Emphasizing population aged over 40 years. • It is desired that health personnel know about screening for diabetes including pre-diabetes. • It is desirable not to suspend screening with MIDO during the pandemic.	• To recommend **screening for DM in adults attending first-level health centres,** which continues despite pandemics.
4) Human resources	• Public health services do not have sufficient human resources to offer uninterrupted screening services due to the pandemic.	• Ensure there are adequate health personnel to carry out screening and early detections of NCDs including DM.	• To recommend that health authorities ensure **adequate training for health personnel in screening for DM**.

	• Pre-diabetes is not a condition identified by health professionals as being important. • Training for health personnel about screening for pre-diabetes is limited and not standardised. • Diseases such as obesity and DM are considered "normal" among health personnel.[164–168]	• Standardise continuing medical education for DM, including the risk of obesity.	
5) Technological and Pharmacological resources	• The supply of screening tests is limited in the State. • The HbA1C available in the health system is only used to follow-up people with DM and is not used in screening e.g. women at risk of gestational DM.	• Purchase sufficient supplies for the screening of DM in at risk populations.	• To request State health authorities to calculate and **purchase sufficient supplies to carry out DM screening** for at-risk populations at first-level health centres and brigades. • To recommend that health authorities **use HbA1C tests for monitoring people with DM.**
6) Information management systems	• First-level health centres have the MIDO System to screen and monitor obesity, hypertension, dyslipidaemia, and DM. When performing a diagnosis, the system automatically synchronises the information in the SIC. • The SIC does not receive information on pre-diseases such as pre-diabetes; however, the MIDO national board refers to a prevalence of 9.6% for pre-diabetes at the national level, and 7.6% for Hidalgo (July 5, 2021).[162]	• Perform MIDO screening on adults attending at first-level health centres. • Allow the SIC system to register people with pre-diabetes for lifestyle advice and follow-up.	• To propose to the national authorities the **incorporation of the pre-diabetes diagnosis into the SIC system.** • To request to the Hidalgo health authorities to carry out **MIDO screening in all adults attending health centres.**

3.4.2. DM Management

Table 35. DM Management; current status, desired status, identified solutions

Health system block (TADDS instrument)	Current status considering the constraints from the Covid-19 Pandemic	Desired status	Identified solutions
1) Priorities, policies, and programmes	• According to the documents reviewed, DM is a national and State health priority. There are regulations and clinical guidelines based on evidence for its prevention, detection and management. These guides also include a document focused on nutrition for the patient with DM (Section 1.3.3). • 80% of the interviewees consider these guidelines as rarely used due to the fact they are not updated, and because their content is limited without clear operational guidelines. • The guidelines do not provide clear strategies for the prevention and management of DM complications.	• Have updated guidelines e.g. every 2 yrs. that consider clear operational strategies for the management of DM, and the prevention and management of complications. This requires a strategy to update clinical and operational guidelines at the State level.	• To create **updated State guidelines** (complementary to the guidelines and national regulations) **for the management of DM**, insulin therapy, and prevention and management of complications related to DM.

2) Health promotion	• Health centres and jurisdictions have comprehensive health promotion strategies for PLWD. Most of this information is given in support groups where DM patients attend to receive health promotion topics and emotional support from health personnel and other DM patients. • The COVID-19 pandemic has suspended group activities at the primary health centres, so support groups have been suspended. • Some health centres make support and follow-up calls via telephone and WhatsApp; however, there is no standardised strategy to offer virtual or digital support or offer health promotion topics.	• Have a standardised State or regional strategy for digital or virtual monitoring and the offer of support and health promotion to patients with DM. Especially for those patients without metabolic control or with the use of insulin. • Establishment of patient support groups at a community level	• To create a State strategy for a standardized health promotion strategy for DM management. Special consideration should be given to those diabetics with poor metabolic control or who are using of insulin.
3) Service provision	• The medical management of DM is initially given in primary-health care centres. • Diabetics have free access to different services; however, the availability of these services depends on the capacities of each health centre to offer them. There is access to a medical consultation, capillary	• It is desirable that rural and urban primary health centres have the resources to guarantee effective consultation and avoid dependence on speciality centres for actions that primary health centres should handle. • Patients should have tools to perform self-monitoring glucose at home with a glucometer, particularly	• To recommend the **identification of the gaps in DM management** and take actions to address them. Mainly for: ▪ Medications like Metformin and Insulin, ▪ Support services like nutritionists, ▪ Supplies for DM monitoring.

	glucose measurement, and access to essential medicines. • Regarding the monitoring of the metabolic status of diabetes, it is not common for a patient to self-monitor glucose at home. • About non-pharmacological care, just a limited number of health centres have nutritionists. This usually occurs in main health centres close to the State capital. • Other support services such as psychologists or a dentist are limited. • Most health centres have support groups for PLWD; however, these activities are cancelled due to the COVID-19 pandemic. • There are no virtual or telephone follow-up strategies for patients with DM. A couple of health centres communicate with some patients through WhatsApp and telephone service paid by the same health personnel.	in times of pandemic where attendance at consultations has decreased considerably. • Decentralise services for PLWD and ensure their operation and access in rural areas. • Have a regional strategy for telephone/virtual follow-up of PLWD without metabolic control or using insulin. • Guarantee the supply of essential drugs for the management of DM, mainly Metformin and Insulin. • Physicians in primary health centres should have the ability to manage insulin regimens in patients with DM to avoid their referral to speciality centres for this reason. • Assign references and medical appointments through digital strategies. • Decentralise speciality services. • Clearly notify the community about the restructuring of services during the pandemic as part of health promotion.	• To recommend a State programme for **self-monitoring of glycaemia at home in patients using insulin** (health centre to provide the glucometer, strips and lancets).[169] • To recommend the creation of a State or regional **telephone/virtual follow-up programme to monitor diabetics using insulin or having poor control.** • To request a reassessment of referral and medical appointment strategies in the State. • To promote **decentralisation of DM speciality care**. .

	• Metformin is commonly used for treating DM. The supply is greater than 80% in all health centres. • Most primary health centre physicians are not trained to manage insulin. • For referring a patient to a specialist (e.g. endocrinologist, ophthalmologist), the requests must be made in paper by the physician. Referrals are managed by the respective health jurisdiction, which slows down the application process. Consultations with specialists depend on their availability. These can take 1-6 months. • The attention of speciality services is centralised to the State capital (Pachuca city). There is only one UNEME operating. The endocrinologists are at the General Hospital of Pachuca. For this reason, care is slow, or patients do not show up for their appointments due to the remoteness of these centres. • During the months with the highest cases of COVID, the health centres		

	limited the provision of routine services due to the adaption physical spaces to care for patients with COVID or due to limited human resources. According to the respondents, the pandemic affected around 40% of the provision of DM care in Hidalgo.		
4) Human resources	• Attention to the COVID-19 pandemic required the redistribution of health professionals in the State, limiting the provision of DM services. Health personnel with risk factors for severe illness from COVID were sent home to work. Health person without risk factors was redistributed to health centres where they required support to offer services not related to COVID. As mentioned in previous sections, the respondents refer that this situation reduced the provision of DM care services by around 40%. • All staff are fully vaccinated against COVID. Most of them received the vaccine from Pfizer. • 90% of the respondents mention that the continuing education	• Have the necessary health personal for the provision of DM care including nutritionists and patient support counselling in living with DM. • Have an updated and standardised continuing education strategy for all health personnel where the management of DM is addressed. Insulin therapy must be considered as a topic of continuing education for physicians in primary health centres.	• To request the health centres and hospitals of the State to have **the necessary health professionals for DM care and its complications.** This according to State possibilities. • To recommend the creation of a standardised and **updated continuing education programme that addresses the management of DM and its complications.** • To propose a **continuing education or certification programme in insulin therapy for first-level physicians.**

	offered at this time is clearly insufficient. • Most of health centres in the State do not have nutritionists. • There is no continuing education plan on insulin use by physicians in primary health centres.		
5) Technological and Pharmacological resources	• The health centres do not have 100% of the supplies necessary for the monitoring and pharmacological management of DM in primary health centres (e.g. biochemical tests, HbA1c, glucometers, medications).	• It is desirable that health centres have 100% of the supplies for the monitoring and management of DM	• To request purchases and distribution of **supplies for the monitoring and management of DM in primary health centres** with the purpose of always having 100% of the necessary supplies.
6) Information management systems	• All primary health centres have the online and offline digital health tool MIDO which is used to perform glucose screening and monitoring of patients with DM. The cases of DM and other NCDs are reported automatically to the SIC; however, some health centres are not attached to the continuous use of this digital health strategy.	• It is desirable that primary health centres use the MIDO strategy standardised in their online and offline versions.	• To recommend the **use of the MIDO digital health strategy in all primary health centres in Hidalgo**.

3.4.3. DR Screening

Table 36. DR Screening; current status, desired status, identified solutions

Health system block (TADDS instrument)	Current status considering the constraints from the Covid-19 Pandemic	Desired status	Identified solutions
1) Priorities, policies, and programmes	• Regulations and clinical guidelines consider DR a national health priority; however, these guidelines only recommend DR screening without additional operational details. • There is no standardised opportunistic or systematic screening strategy at the national or State level for DR screening. • In Hidalgo, DR screening is opportunistic and with some non-standardised eye health brigades.	• Have a national or State opportunistic or systematic screening strategy with clear operating processes. • Systematic screening is desirable because more than 4% of the population suffers from unknown DM.[162]	• To propose **opportunistic DR screening** based on the availability of treatment services. (It could later be followed by a systematic screening programme. This strategy should be done with strengthening the capacity to treat DR in Hidalgo (see following sections).
2) Health promotion	• There is a health promotion strategy for diabetics where DR is addressed as a complication. However, the information is insufficient for the patient with DM.	• It is desirable to review and improve the guidelines and health promotion materials on DR. • ? Counselling all DM patients on the importance of glycaemic	• To review and improve **health promotion guidelines for PLWD where the topic of DR is fully addressed.**

	• It is not certain that these strategies are used at the State level or in mobile brigades to rural populations.	control and regular eye health checks	
3) Service provision	• Primary-health centres perform opportunistic DR screening; however, most health personnel do not have the capacity or supplies (ophthalmoscope) to perform a quality fundus evaluation. • 50% of the respondents mention that patients with DM are not systematically referred for ophthalmological evaluation. More than 80% of the respondents mentioned that they do not refer asymptomatic diabetics to eye health services. • There are no standardised operational strategies for screening at the community level. • Retinal photography services are not offered in the community for evaluation by trained personnel or supported by telemedicine.	• Perform opportunistic screening at primary health centres. • Have a standardised strategy for taking fundus photos evaluated by trained personnel at the primary health centre, jurisdiction or secondary hospital with eye care services. • Have telemedicine strategies to carry out Retinal imaging screening in regions where opportunistic screening is not possible.	• To recommend the implementation of an **opportunistic screening strategy** to examine the fundus of all DM patients once a year when attending health centres. • To recommend **investment in the capacity to take fundus photographs** for assessment in secondary hospitals with eye care services and primary health centres and.

4) Human resources	• Health personnel in health centres are not trained to perform fundus evaluations properly. • There are no technical health personnel or professional training to perform a retinal photographic evaluation. • The eye health personnel is limited and only present in two hospitals in the cities of Pachuca and Tulancingo.	• Have ongoing training in fundus assessment and retinal photographic evaluation to perform opportunistic DR screening in people with DM in primary health centres or brigades in rural areas.	• To recommend **screening for DR in patients with DM in health centres and brigades:** Ideally using fundus cameras so that retinal images can be graded by trained personal; and if this is not feasible, then to train health personal in fundus evaluation and ensure that ophthalmoscopes are available at health centres and to brigades. • To create **updated and standardised continuous training to carry out activities related to DR screening**.
5) Technological and Pharmacological resources	• Not all health centres have ophthalmoscopes. • Primary health centres do not have retinal cameras to perform DR screening.	• It is desirable that the primary health centres and mobile brigades have ophthalmoscopes and cameras for all retinal photography in the population with DM.	• To ensure access to dilating drops and **retinal photography capacity in secondary level care and facilities designated to carry out DR screenings.**
6) Information management systems	• There is no epidemiological reporting strategy for DR screening results. • There is no strategy for referring patients with DM to second-level hospitals with eye health areas once screening is suspicious or positive.	• Have epidemiological reports of the RD screening results that are performed. • It is desirable that the SIC system record the diagnosis of DR. • Have a functional and straightforward strategy for referring patients with DM to eye	• To propose the creation of a system for **recording and reporting the results of DR screening**. - create a database. • To request the authorities and the Carlos Slim Foundation to **incorporate the DR diagnosis into**

		health areas in second-level hospitals.	**the national dashboard of the SIC system.** • To propose the creation of a **standardised referral system for eye health services in second-level hospitals.** • To propose a call and recall system for regular **(annual) check-ups for all DM patients**

3.4.4. DR Management & follow-up

Table 37. DR Management & follow-up; current status, desired status, identified solutions

Health system block (TADDS instrument)	Current status considering the constraints from the Covid-19 Pandemic	Desired status	Identified solutions
1) Priorities, policies, and programmes	• Respondents consider that DR is a priority issue in public health for Mexico, but they do not perceive it to be an operational priority. • In Mexico, there is only a reference guide for the diagnosis and treatment of DR. Its last update was in 2015, without being the result of a consensus among all health institutions in the country.	• It is desirable that the DR be considered an operational priority health issue for Mexico. • Detailed clinical guidelines for the management of DR are desirable.	• To promote with MoH the **importance of DR as a health priority** in Mexico and Hidalgo. • To recommend to the National and State health authorities the creation of **updated guidelines for the management of DR** that propose at least annual eye examination to all people with DR to look for VTDR.
2) Health promotion	• Health promotion strategies focused on patients with DR are exclusive of eye health services. There are no standardised strategies at the state level.	• It is desirable that standardised educational prevention and health promotion strategies focused on patients with DM and DR	• To create standardised **health education and promotion guides to be offered to patients with DM, DR and VTRD** in primary health centres and eye health services.
3) Service provision	• DR management occurs in two centralised eye health services in the regions of Pachuca and Tulancingo. Their capacity is limited	• Have eye health services that serve DR in all regions of the State. • It is desirable that services related to eye health are provided to	• To recommend the **opening of eye health services with the capacity to manage and follow up patients with DR in other regions of Hidalgo.**

	and not enough to respond to the epidemiological need in the region. • The Tulancingo hospital also receives population from other States such as Veracruz. • As other regions away from the capital of Hidalgo do not have eye health care units, the treatment of DR becomes an out-of-pocket expense for patients (for those patients with economic resources to look for private services). Patients without economic resources usually do not have any medical care. • As mentioned in other sections, during the pandemic, only the Pachuca general hospital partially offered eye health services because the Tulancingo hospital became a COVID hospital without a strategy to transfer eye health services to another location or make private-public alliances to continue providing eye health services. Those who cannot afford private health services remained without treatments.	patients with DR during the pandemic, this could be possible by transferring eye health services or making public-private partnerships.	• To advise **avoiding the closure of eye health services during** the COVID-19 pandemic. This can be by transferring eye health services to other locations or making public-private alliances to care for patients with DR.

4) Human resources	• The number of eye health professionals capable of managing DR is limited in Hidalgo. The presence of this personnel is centralised to only two regions of the State. • During the months of more COVID cases, some health professionals capable of handling DR did not go to eye health services due to the partial closure of services or were required to attend COVID patients.	• Have enough professionals capable of treating patients with DR in current eye health services, and expand this capacity in other regions of the State.	• To recommend **training more health professionals to manage DR**. This is to reinforce the eye health services currently in operation, and to have personnel in regions where new eye health services are needed the most.
5) Technological and Pharmacological resources	• Lasers and antiVEGF intravitreal injections for the management of DR are only available in two eye health services in the State. In the opinion of the interviewees, this offer is insufficient to meet the demand of patients with DR in Hidalgo.	• Have the technological and medical resources to serve the population currently seeking DR treatment in the eye health services currently operating. • Extend the coverage of these technologies in other areas of the State.	• To **provide the equipment to manage DR** in the eye health services currently operating. • To recommend **decentralising the technologies and capacities necessary for DR care** in other regions of the State, in particular access to lasers and antiVEGF intravitreal injections.
6) Information management systems	• The prevalence of DR in Mexico is not measured. • There are no management systems for referring patients with DR to	• Have epidemiological reports focused on the burden of DR. • Have a functional and straightforward system for referring	• To propose the creation of a system to **report the incidence and prevalence of DR.**

	second-level hospitals with eye health areas.	DR patients to eye health services in second-level hospitals.	• To recommend to the authorities and the Carlos Slim Foundation to **incorporate the DR diagnosis into the national dashboard of the SIC system.** • To propose the creation of a **standardised referral system for eye health services** in second-level hospitals.

3.4.5 VTDR Treatment and Rehabilitation

Table 38. VTDR Treatment and Rehabilitation; current status, desired status, identified solutions

Health system block (TADDS instrument)	Current status considering the constraints from the Covid-19 Pandemic	Desired status	Identified solutions
1) Priorities, policies, and programmes	• The only available clinical guideline for DR does not cover details for the management of VTDR. This guide only mentions that the management of VTDR is handled at the second or third level of care. • The State of Hidalgo does not have clinical guidelines for the management of VTDR.	• Have national or State guides that are constantly updated for the management of RD and VTDR where the operational strategies and medical referrals are specified among the three levels of care.	• To propose creating national or State **guidelines for the management of VTDR**.
2) Health promotion	• Health promotion strategies for patients with DR or VTDR are exclusive to second-level eye health services. There are no standardised strategies at the state level.	• It is desirable that educational prevention and health promotion strategies for RD and VTDR patients are offered following a standardised strategy in primary health centres and eye health services in second-level hospitals.	• To create standardised **health education and promotion guides to be offered to patients with DM, DR and VRTD** in primary health centres and eye health services.
3) Service provision	• VTDR management (lasers or antiVEGF intravitreal injections) is centralised in two second-level	• Decentralise eye health care and the capacity to serve VTDR in Hidalgo.	• To recommend the **opening of centres for eye health care and VTDR management in other regions of the State**.

	hospitals (in the cities of Pachuca and Tulancingo. Before the pandemic, this capacity of care was limited due to the two eye health services of the State attend to any type of eye problem and resources were limited. The Tulancingo hospital suspended eye health care services due to the pandemic. The General Hospital of Pachuca is offering limited services. Figure 14 presents the frequency of eye health services offered during the pandemic months by second-level hospitals in Hidalgo.	• Maintain services for eye health care and management of VTDR during the pandemic by seeking its operation in non-COVID areas. • Consider the reopening of the Tulancingo eye health service to provide care for population with VTDR in that region.	• To advise on the importance of **not closing eye health services i**n the State during the COVID-19 pandemic.
4) Human resources	• The number of eye health professionals capable of handling VTDR is limited in Hidalgo. The presence of this personnel is centralised to only two regions of the State. • During the months of more COVID cases, some health professionals	• Increase the number of health personnel capable of managing VTDR to reinforce the capacity of the eye health services currently in operation and provide these professionals in other regions of the State as new areas are opened. • It is important not to close eye health services during the pandemic.	• To aim **for 1 laser and 1 ophthalmologist trained to treat DR per 250,000 population** distributed according to the epidemiological need of Hidalgo. Based on the current State population, this translates to 12 lasers and 12 ophthalmologists trained to treat DR. It is important to emphasise the need to expand this capacity

	capable of handling VTDR did not offered services.		because at the moment these services are only available in the state capital.
5) Technological and Pharmacological resources	• The technologies for the management of VTDR are centralised in two eye health services in the State. In the opinion of the interviewees, these technologies are insufficient to meet the demand of patients with DR and VTDR.	• Have the technological resources to serve the population currently seeking VTDR treatment in the eye services currently operating. • Extend the coverage of these technologies in other areas of the State.	To ensure the **availability of lasers or anti-VEGF intravitreal injections** according to the epidemiological need of Hidalgo. To promote the idea of distributing this capacity in other regions of the State.
6) Information management systems	• At this time, there are no epidemiological reports of VTDR, so the current disease burden is not known.	• Have epidemiological reports of VTDR cases to know the burden of the disease and its distribution in the State.	• To propose new epidemiological instruments that can **report VTDR statistics** in the State and their geographical distribution.

4. DISCUSSION

In the first part I will discuss the strengths and limitations of this study. Then I will discuss the current and future magnitude of DM and DR in Mexico in order to understand the scale of the need. Once the epidemiological framework is understood I will consider the findings from the TADDS assessment of the public health system in Hidalgo for DM and DR, in particular the constraints on health providers in the public sector in Hidalgo State resulting from the COVID-19 epidemic in delivering services for PLWD. Finally, I will propose possible solutions to address these constraints in the context of the need and conclude with a summary of conclusions and practical recommendations primarily relevant to Hidalgo State but which could also be applicable for other States in Mexico.

4.1. Study limitations and strengths

Limitations

The 13 key stakeholders, from national and regional policymakers, implementers, and civil society actors do not fully represent the national public health system for DM and DR. Given the limitations of lock down due to the COVID-19 pandemic some stakeholders who I wished to interview were not available and the 13 interviews that were undertaken had to be undertaken via Zoom, not face to face. Having said that the interviewees did come from national and state policy levels, as well as those involved in the delivery of services for PLWD and eye health services.

Due to the COVID-19 pandemic, it was not possible to interview PLWD as was originally planned, therefore, this work focussed on the constraints perceived by health providers rather than health recipients. The original study objectives and plan which included interviewing PLWD were adapted because of COVID in order to consider the impact of COVID on services for PLWD particularly eye health services.

In the positivistic approach to research, the position of the researcher should remain invisible.[108] For this study, the researcher tried not to influence the interviewees in taking any particular position or by offering information according to the researcher's understanding of the phenomenon. However, some bias due to the researcher's presence, own knowledge and experience may have influenced the answers of interviewees and the interpretation of the answers by the researcher.

In the implementation of the TADDS instrument, the values that represent a ranking score on the health system blocks are based on the opinion of the stakeholders, so this information should be taken with caution when comparing these scores with other studies using the same instrument. Other studies using the TADDS instrument in Nepal and Iran [127,128] have also focussed on the stakeholders perspective.

The stakeholders who participated in this study reported not knowing details of the financing of DM and DR services. In addition, it was not possible to review financial documents as this was not authorized by the authorities of Hidalgo at the time of the analysis possibly due to their attention to the COVID-19 pandemic. It is suggested that further studies be carried out to explore the financing

of services focused on the prevention, detection and management of DM and DR in Mexico and Hidalgo.

Strengths

To my knowledge, this is the first work carried out to assess the public health system for DR service provision in Mexico, and in particular the State of Hidalgo. At the national level there have been a few published articles on the prevalence of DR in Mexico,[170–172] as well as a study published by the DR Barometer in 2017.[173] Carrillo has investigated and published papers on DR in the State of Hidalgo.[172,64]

A strength of this work is the combination of quantitative and qualitative research. This work investigated the opinion and experience of 13 main stakeholders who participate in decision-making and implementation of services to manage DM and DR at the national and State level. The study used a recognised WHO tool, (TADDS) that allows a systematic evaluation of the building blocks of a health system using DM as the "tracking disease", and these results are reinforced by identifying constraints and possible solutions in the provision of care for DM and DR during the COVID-19 pandemic.

4.2. Importance of Diabetes Mellitus and Diabetic Retinopathy in Mexico and Hidalgo

The importance of DM as a cause of mortality and morbidity globally and in Mexico

DM is considered one of the priority NCDs and one of the ten top causes of mortality worldwide. It is also a major cause of disability.[1]

In Mexico, the proportion of deaths and disability-related life-years due to DM is among the highest in the world being associated with a high prevalence of obesity.[162,174]

The most recent GBD study shows that between 2009 and 2019 the six leading causes of death for all ages in Mexico are NCDs, with DM moving from the third to second place in 2019 after ischemic heart disease.[40,175] The same study reports a nearly 50% increase in DALYs (deaths and disabilities combined) between 2009 and 2019 in Mexico.[40]

The current need in Mexico and Hidalgo for services to address DM, DR and VTDR.

In order to understand, plan and deliver a system of screening, detection, referral, management, and rehabilitation for DR, it is necessary to know the burden of disease for a population. Although Mexico has a high prevalence of DM, information on the burden of DR in Mexico is limited.

The calculations for DR and VTDR for Mexico in this thesis are based on the review by Teo and colleagues in a recent systematic review and meta-analysis in 2021.[32]

Teo and colleagues build on the previous review by Yau.[30] This systematic review includes 59 studies which conclude that the overall prevalence for DR in PLWD is 22.7% and 6.1% for VTDR. However, on analysing each region, NAC has a DR prevalence of 33.3%.[32] This analysis does not present specific information for Mexico, so this work uses the prevalence reported for the NAC region for Mexico.

It is important in the future to study the prevalence of DR and VTDR in Mexican populations as these conditions could vary based on ethnicity,[176] and metabolic control among diabetics.

Based upon population projections, reports of the prevalence of DM and the review of DR in PLWD by Teo, Table 14 shows the estimates of DM, DR and VTDR in the population aged 20 years and over in Mexico for the year 2020.
The estimated adult population with DM in Mexico for 2020 is 11.229 million with 3.739million diabetics having some DR, and 0.875 million needing treatment for VTDR.
Assuming a population of 130 million people in Mexico in 2020 then for every 1 million people there are an estimated 86,400 people living with diabetes of whom 28,000 have DR and 6,700 need treatment for VTDR.

Table 39. Estimations of DM, DR and VTDR in the population aged 20 years and over

Total Population (130million) for every …	**1,000 general pop.**	**100,000 general pop.**	**1,000,000 general pop.**
Population aged 20 years and over (64%)	640	64,000	640,000
Prev. of DM in 20yrs + pop	13.5%		
Number of people living with diabetes	86	8,640	86,400
Proportion of PLWD having any DR	33.3%		
Number PLWD with any DR	28	2,800	28,000
Proportion of PLWD having VTDR	7.8%		
Number PLWD with VTDR (i.e. requiring treatment)	7	670	6,700

It is estimated that severe visual impairment due DR is responsible for 161,159 lost DALYs in Mexico (Table 14).
Similarly, Table 15 shows the estimates of DM, DR and VTDR for the State of Hidalgo.
In 2020 272,000 are estimated to have DM in Hidalgo with approximately 90,000 having some DR, and 21,000 needing treatment for VTDR.

Projections for 2030 and 2050

The national population projections for Mexico estimate the population over 20 years of age to increase by 14.9% and 34.6% by 2030 and 2050, respectively.[147,148] For the State of Hidalgo, these estimations consider an increase of 15.4% and 40.9% respectively for 2030 and 2050 based on the 2020 population. This demographic change is of public health relevance because with the increasing proportion of adults in the coming years, the prevalence of NCDs such as DM and its complications is expected to increase.[177]

Table 14 shows the estimates of DM, DR and VTDR in the population aged 20 years and over in Mexico for the year 2030 and 2050. The population with DM is estimated to increase by 25.9% and 53.5% by 2030 and 2050. The magnitude of DR and VRTD is estimated to have a similar increase in the absence of concrete actions to prevent DM and DR. Similarly, Table 15 shows the same projections for the State of Hidalgo.

These estimations from epidemiologic data are important for advocacy and for planning. They imply improvements are required in the health system to meet the current need and also to adapt to the demographic challenges projected for the next 10-30 years.

Continuum of Care

Understanding the strategies required to address DR in Mexico depends on understanding the DM-DR continuum of care. Figure 19 shows the possible activities at different levels of the health care system for DM and DR prevention and screening.

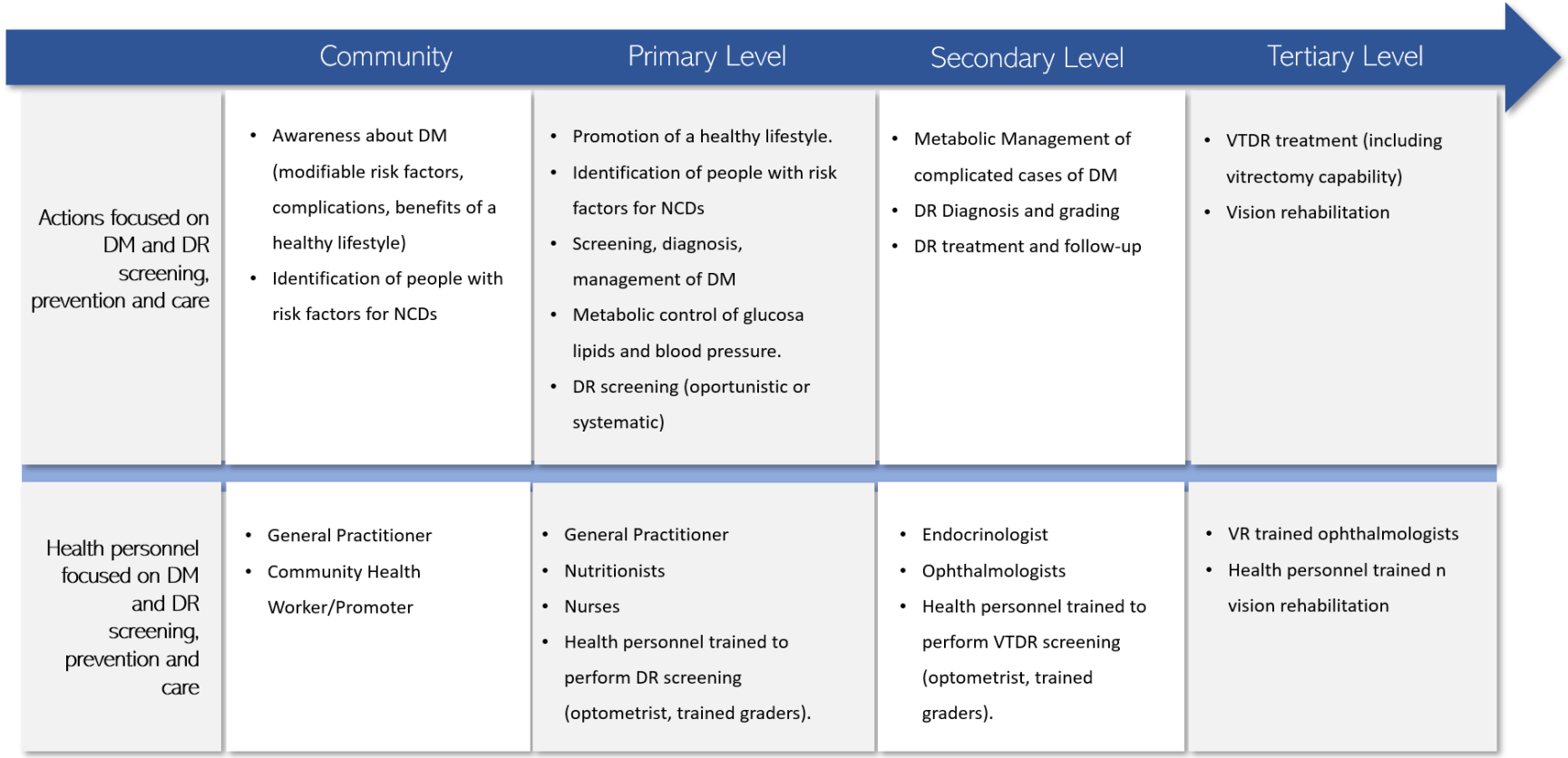
Key measures to prevent vision loss from DR

The first and most important measure to prevent DR is to prevent DM. This in itself requires an understanding and activities to reduce the modifiable risk factors for DM, in particular obesity and sedentary lifestyles.[40,175]

The second important action to prevent DR is to ensure good control of hyperglycaemia in PLWD by early detection and appropriate management.

The third measure is the identification of PLWD who have DR through screening and the provision of treatment to those with VTDR to prevent blindness

Figure 19. The activities and required health staff for DM and DR prevention, screening and care according to the level of service



Preventing DR

DR is an important complication of DM, which can progress from non-proliferative abnormalities (NPDR) with the formation of microaneurysms to severe and proliferative disease with retinal capillary and arteriolar obstructions, haemorrhages, and the proliferation of new vessels (Figure 2).
Macular Oedema (DMO) can also occur at any stage due to increased blood vessel permeability, causing loss of visual acuity because the macula is responsible for central detailed vision.

The duration of DM is an important risk factor for DR. The Wisconsin Epidemiologic Study of Diabetic Retinopathy (WESDR) reported a prevalence of DR of 8% three years after the onset of DM, reaching 80% 15 years after the onset of DM. The same study reported a prevalence of PDR of 0% at three years increasing to approximately 25% at 15 years.[178]

The severity and the onset of complications also depends on the glucose levels. The Action to Control Cardiovascular Risk in Diabetes (ACCORD) Study, described development of DR being significantly lower in those diabetics with good glycaemic control (HbA1c <6%).[179]

The follow-up study Action to Control Cardiovascular Risk in Diabetes Follow-On (ACCORDION) reported that DR progression was less in diabetics with good metabolic control (HbA1c<6%) compared to 1 those with higher HbA1c (5.8% vs 12.7%) , adjusted OR of 0.42 (95% CI 95%: 0.28-0.63).[180]

The UK Prospective Diabetes Study (UKPDS) showed that for each percentage point reduction in HbA1c the relative risk for cardiovascular complications reduced by 37%. The risk of DM-related death also reduced by 21%.[181,182]

The UKPDS study also showed the importance of comorbidity with hypertension reporting that after ten years of following diabetics with hypertension, the reduction in development of DR was 34% in diabetics who achieved a blood pressure <150/85 mmHg compared to those with a higher values. [183]

Setting the target of HbA1C <7% continues to be the main cost-effective strategy for preventing the onset and progression of DR.

Screening for DR

The aim of screening is to identify disease early at a stage when treatment is likely to be more successful. Public health screening programmes are based on epidemiological evidence and a clear understanding of disease progression and treatment. These strategies must be cost-effective, easy to use, and cause as little inconvenience to the population as possible in order to be accepted.

The purpose of a screening test is to identify individuals who may have the disease, rather than to make a definitive diagnosis. Individuals with positive or uncertain results should be referred to verify a diagnosis and start treatment if necessary.[184]
Screening tests should:

- Determine the presence of disease in asymptomatic populations or individuals at risk of a given disease.
- determine the health status of a population.
- encourage preventive measures once the extent of the problem is known.
- identify high risk individuals in order to implement interventions among them.

The selection of a screening test should consider the following elements:[184,185]

- High sensitivity (miss few true positives)

- Validity of the test (sensitivity and specificity – do not overload the system with false positives).
- Reproducibility: ability of the test to give the same result when applied repeatedly.
- Feasibility: for a test to be feasible to perform within a screening program, it must be safe and accepted by the population.

Early detection of DR is essential to prevent blindness. Early detection by screening can be opportunistic or systematic. Scanlon and colleagues describe four steps for the development of a screening programme for the detection of VTDR:[186]

1. Ensure access to treatment. Have a minimum of one laser per 100,000/population with a maximum waiting period of 3 months between diagnosis and treatment. However, it is important to consider that The DR clinical guidelines for Latin America of the Pan American Association of Ophthalmologists suggest having one laser per 250,000-500,000 in the countries of the region.[187]
2. Establish an opportunistic screening strategy: Dilated fundoscopy is recommended at the time of attending routine health services. Ensure annual assessments. Have operational guidelines for implementation and referrals to eye health centres.
3. Establish a systematic screening strategy: Ensure annual screening of people with DM. Maintaining a registry of cases. Use screening strategies with sensitivity >80%, a specificity >90% and a coverage >80%.
4. Establish a quality systematic screening strategy that ensures full coverage. With full certification among all operators in the strategy, and with both a clinical and operational monitoring and evaluation system.

The following table lists the main screening methods and their respective sensitivity for the detection of DR or VTDR. The last column mentions the availability of these tests within the State of Hidalgo.

Table 40. Screening test for DR or VTDR, sensitivity, specificity, and availability in Hidalgo State

#	Screening Method	Sensitivity and Specificity (95% CIs)	Availability in Hidalgo
1	Direct ophthalmoscopy[186,188]	Sensitivity: 65% for VTDR (95% CI 51-79%)	93% of primary health centres have ophthalmoscopies[189]
2	Slit lamp biomicroscopy by Optometrist[190]	Sensitivity: 73% (52–88%) Specificity: 90% (87–93%)	Only available in the eye health centres of Tulancingo and Pachuca.
3	Mydriatic photography (< seven fields) using 35 mm film or Polaroid[191]	For all retinopathy: Sensitivity: 89% Specificity: 89%	Not Reported
4	Non-mydriatic photography[192]	By trained technicians: Sensitivity: 86% Graded by retinal specialist: Sensitivity: 98% Specificity: 100%	Not Reported
5	Mydriatic digital photography[190]	Sensitivity: 93% (82–98%) Specificity: 87% (84–90%)	Only available in the eye health centres of Tulancingo and Pachuca.

The selection of the most appropriate screening method for the health system and its context are important for the success of the screening programme for DR. A screening programme requires considerable investment in infrastructure and personnel, and it is essential that good referral and treatment services are available.[186] This can be a problem for low- and middle-income countries due to their limited implementation capacity. Piyasena and colleagues in a systematic review describe that some of the most important health system-related barriers to accessing DR screening are lack of trained personnel, lack of established training programmes and inadequate retinal imaging infrastructure, as well as the high cost of services.[193]

Grading DR

Tables 2 and 3, and Figure 2 (Section 1.2) describe the different stages of DR and DMO. The correct identification of these stages is very important in deciding on management, follow-up and treatment, the degree of urgency for referral to an ophthalmologist depends on accurate grading.

Of the different grading schemes available, the Early Treatment of Diabetic Retinopathy Study (EDTRS) classification is the one recommended in Mexico by the national clinical guideline for the detection of DR .[50] This protocol allows for the identification of five different stages of DR and three for DMO, consistent with the clinical classification provided by ICO (Figure 2).[28,29]

Diabetics without any retinopathy require reassessment after 1 to 2 years, and therapeutic strategies focus on good metabolic control. For patients with DR, it is necessary to identify those patients with VTDR who need an urgent referral and treatment to prevent visual loss. Tables 4 and 5 (Section 2) describes the frequency to examine the retina and when to refer patients for further assessment and treatment for each stage of DR and DMO.

Treating DR and VTDR

The major developments in the treatment of DR have been:

- In 1978 evidence for the efficacy of PRP by the Diabetic Retinopathy Study (DRS);[194]
- In 1985 evidence for the efficacy of focal laser application for DMO management by the ETDRS;[195]
- In 1998 evidence that glycaemic control reduces the risk of developing DR by the UKPDS;[196]
- In 2010 evidence of the efficacy of anti-VEGF for the treatment of DMO;[197]
- In 2015 evidence for the efficacy of anti-VEGF for the reduction of the risk of progression of PDR.[198]

The current management of DR is based on these milestones.

The approach to DR is to prevent vision loss through different treatment strategies with patient-centred treatment and follow-up.[199]

Vision loss occurs due to clinically significant DMO or proliferative disease with haemorrhage and retinal detachment.[200]

The use of intravitreal injections of anti-VEGF blocks the effect of endothelial growth factor and can reduce macula oedema.[201] The use of anti-VEGF therapy depends on repeated administration, requires trained health personnel and is therefore costly; it also requires patient compliance. Focal laser treatment to the peri-macular area has also been used to decrease macula oedema in patients with DMO.[202]

For PDR pan-retinal photocoagulation is used to decrease the production of endothelial growth factor from ischaemic retina by destroying areas of the retinal periphery. However its use can affect peripheral vision and diminish vision at night.[203] A recent meta-analysis of systematic reviews showed that the use of anti-VEGF is associated with better visual acuity outcomes either alone or combined with PRP.[204]

Vitrectomy is performed to treat vitreous haemorrhage that does not resolve spontaneously, and vitreo-retinal surgery may be performed to treat tractional retinal detachment. [187,205]

4.3. Constraints in the provision of health care for persons living with DM/DR

Having assessed the magnitude of DM and DR in Mexico and Hidalgo for 2020 and the estimates for 2030 and 2050, it is important to try and understand the major constraints and how the health system can respond to provide a continuum of care for persons with DM and DR.

National Policies

This work found that DM is considered a national public health priority in Mexico and Hidalgo by the relevant key stakeholders. This is confirmed in the guidelines currently available for the country's three levels of health care (see section 1.3.3). From these documents, the Official Mexican NOM [PROY-NOM-015-SSA2-2018] for the prevention, treatment and control of DM is the guiding document for public health actions that are to be followed at the national level.[48] In addition, the Clinical care algorithms for Type 2 Diabetes issued by CENETEC in 2018 is another document based on the Official Mexican NOM, and is considered the guiding document for clinical management in the country.[49]

Although the last update was carried out in 2018, the main information published in both documents continue to be relevant and in line with the recommendations of the ADA 2021,[6] which is the international institution that has the most clinical influence on DM issues in Mexico.
The main constraints around the policies identified in this study are:

1. The guideline documents are not reviewed and updated every 3 years.
2. The guidelines do not consider health promotion to prevent DM in people with risk factors such as obesity, hypertension, or pre-diabetes.
3. Although the diagnostic and clinical management criteria are clear and valid for therapies, they do not provide operational guidelines for the three levels of health care, for example regarding purchase of essential medicines, distribution, and reporting.
4. The guidelines do not provide strategies for the prevention and management of complications of DM, in particular DR.

Financial Resources

Policies need to be backed up by resources. In terms of health expenditure, according to World Bank figures for 2018, Mexico invested 5.4% of its GDP in health (6% is recommended by the Pan American Health Organization).[206] In contrast, the United States and the United Kingdom invested 16.9% and 10.0% respectively for the same year. Table 41 describes the health expenditure per capita in 2019 in 9 countries members of the Organization for Economic Co-operation and Development (OECD);[198] Mexico reported an expenditure on health of $1,154 per capita, lower than Colombia ($1,213 per capita) and one tenth that of the United States ($11,072/per capita). The low per capita investment in health in Mexico is related to the overall economic development of the country, but also the priority placed on the health of the population by the government.

Table 41. Health expenditure per capita in 2019 in nine countries of the OCDE

Country	Health Expenditure GDP/capita PPP US$ in 2019
United States	11,072
Germany	6,646
Canada	5,418
United Kingdom	4,653
Spain	3,616
South Korea	3,384
Portugal	3,379
Colombia	1,213
Mexico	1,154

GDP: *Gross domestic product;* ***PPP:*** *Purchasing power parity;* ***US$:*** *US Dollars*

The UK spends approximately 10% of its national health budget on continuing care for people with diabetes, representing £14 billion in a year;[207] while in the United States, the ADA reported the total estimated cost designated to DM care in 2017 at USD $327 billion.[208,209]

Provision of Services for those with DM /DR

Policies also need to be put into practice through action plans. In the absence of specific government action plans to address DM/DR, the Carlos Slim Foundation developed electronic health initiatives for the care of adults having NCDs. The prevention, early detection and control of DM is one of the main diseases addressed by of these programmes. The creation of the electronic health tool was carried out with the national health secretariat so that the Foundation is in charge of developing the electronic tools, and the health secretariat is in charge of implementing them within its National and State programs.

There are two specific electronic tools used by public health institutions in Mexico called SIC (in Spanish: *Sistema Nacional de Información en Enfermedades Crónicas*), which is a national system for reporting chronic diseases and MIDO. MIDO (Integrated measurement for timely detection in English) is used to report glucose, blood pressure and weight of all adults who visit a primary health centre. MIDO documents 21 indicators based on measurements and health history.[210] It provides health professionals and adults with specific recommendations according to the results. These recommendations include physical activity, nutrition and awareness of each person's risk factors for progression to an NCD or pre-disease stage.[162,163] MIDO also offers the same information for pregnant-women, about early detection of GDM and pre-gestational DM.

MIDO is currently available in 1,107 primary health centres in Mexico and has evaluated about 2.5 million adults. The use of MIDO is operationally dependent on the measurement of glucose, blood pressure and weight which depend on there being instruments available at each health centre. According to the MIDO national dashboard, of the 2.5 million people assessed by April 2021, 99.2% had a weight measurement, 99.4% had a blood pressure measurement, but only 85.1% had glucose measurements.[162] In addition, the MIDO national pregnancy dashboard shows that the cumulative proportion of pregnant women detected with GDM for the same period is less than 1% of the approx. 15% expected for Mexico.[211,212] This may indicate a lack of capacity to perform screening tests such as OGTT between the 24th and 28th week of pregnancy.

According to the stakeholders interviewed in this work, although Mexico has an important electronic health tool (MIDO) for screening, timely detection, follow-up, health promotion and notification of NCDs in adults and pregnant women, there is a lack of supplies and human resources to consistently operate this tool which limits its capacity.

An additional observation was that in the opinion of some interviewees, it is important to consider pre-diabetes due to its high prevalence. The national MIDO dashboard has reported a prevalence of pre-diabetes in Mexico of 9.6%, and 7.6% for Hidalgo.[10] According to some interviewees pre-diabetes is not discussed in continuing education for health care professionals, and it is not present in the limited documents on health promotion in the state of Hidalgo. This awareness of pre-diabetes is important in order to promote strategies against the risk factors for DM in those identified with pre-diabetes.

Management of DM and Control of Hyperglycaemia

The management of DM mainly takes place in primary health centres. Only those cases with difficult metabolic control or those who require specialised follow-up are referred to second or third level care centres or medical speciality units (UNEME).

A priority for the prevention of DR is the control of glucose and lipid levels in DM.[187] The MIDO system in the primary health centres reports to the national system for chronic diseases (SIC) all new diagnoses found as well as information related to metabolic control such as glucose, HbA1c, blood pressure and lipid values.[210] According to the national dashboard of the SIC (April 2021), 41.9% of patients with DM in Mexico have had an HbA1C measurement in the last 12 months, of which 53.6% have a value higher than 7%. In addition to this data, ENSANUT describes that in 2017 the diabetic population in Mexico with glucose values >130mg/dL was 68.9%,[213] one of the highest in Latin America .[214] For Hidalgo, the SIC reports that 74.5% of diabetics having an HbA1c measurement, of which 50.2% of the values are higher than 7%.[116] Also according to the SIC report of 7.2% and 7.8% of PLWD have dyslipidaemia in Mexico and Hidalgo respectively, and 8.3% and 19.3% have hypertension. A disturbing statistic is the percentage of diabetics who are under the diagnosis of metabolic syndrome (metabolic syndrome is defined as DM with at least two other comorbidities from obesity, dyslipidaemia and hypertension) which is 36% for Mexico and 40% for Hidalgo.[116] These figures suggest the need to improve metabolic control strategies in patients with DM.

Constraints to Provision of DM/DR Services

The major constraints which were identified by the health service provider stakeholders are:

1) **Lack of training of primary care physicians:**
   Primary care physicians avoid prescribing insulin because of lack of training and expertise with insulin, so patients with difficult metabolic control are referred to second level centres. This results in either persons not attending or overload of secondary level services.
2) **Insufficient health professionals for DM care:**
   Not all health centres have the necessary health professionals to provide care for patients with DM/DR. In particular there is a lack of nutritionists, so advice on diet is limited. Endocrinologists are in the second level hospitals where there is overcrowding due to the unnecessary referral of patients with DM for metabolic control with insulin. Ophthalmologists are only present in eye health centres in second levels hospitals, of which only one centre operates in the whole State due to the conversion of hospitals and services for the care of COVID patients. The presence of optometrists is also limited, and they mainly give spectacle prescriptions and do not screen PLWD.
3) **Lack of supplies and medicines:**
   Respondents, both decision-makers and implementers, reported that most health centres do not have the necessary supplies to care for the DM population (specifically metformin and insulin). The availability of supplies and medicines is limited due to the centralization in purchasing supplies and medicines by the Federal Government which began in 2019; before then each States made purchases according to the need of health centres and hospitals. [215]
4) **Centralisation of specialist care in state capitals:**
   The specialist services are centralised and overcrowded, so that in the opinion of implementers, to see a specialist one can wait 4 and 8 months. The distribution of the UNEMES is only in main urban cities. In Hidalgo there are four UNEMES in the capital (Pachuca), however only one centre is actually working, so its service is overloaded, leaving patients who require metabolic control by specialists unattended. Likewise, the second level hospitals are located in the main cities, generating a problem of access for patients due to economic and geographic barriers.
5) **Inefficient referral system:**
   There is no electronic system for medical referrals or appointment scheduling. This leads to delays in the referral of a patient with DM who needs attention at the second or third level of care.

Specific Constraints to the Management of DR

It is estimated that in Mexico there are 3.7 million diabetics with DR, of which 1.1 million need treatment for VTDR. In Hidalgo, it is estimated that 90,000 diabetics have DR and 21,000 people need treatment for VTDR.

a) Guidelines

DR is undoubtedly a public health problem for Mexico, however, unlike DM, national guidelines fail to provide specific recommendations for screening, management, treatment, and follow-up of people with DR. The Official Mexican NOM for the prevention, treatment and control of diabetes mellitus, recognises DR as one of the complications of DM that should be monitored, however it does not give specific recommendations for its detection and management.[48] The clinical practice guide for the diagnosis and treatment of diabetic retinopathy, issued by CENETEC in 2015,[50] provides general information and one clinical flowchart for the management of patients with DR. Apart from these two documents, Mexico does not have guidelines for screening, management, treatment, and follow-up of people with DR.

b) Limited screening for DR

Any screening for DR that is done at present is opportunistic and within primary health centres by general practitioners using direct ophthalmoscopy. It should be noted that the sensitivity of direct ophthalmoscopy is limited, therefore training of general practitioners is essential to increase the sensitivity if direct ophthalmoscopy is used.[216]. According to the 2018 infrastructure report of the Ministry of Health, 88% of primary health care centres in Mexico had an ophthalmoscope, and in Hidalgo the figure was 93%. However the current situation during the COVID-19 pandemic is not known.[189] Some interviewees said that although direct ophthalmoscopes are available in most primary health centres often they do not function and that general practitioners do not have the knowledge to perform an adequate fundus examination. This situation results in patients with DM being referred to one of the two eye health centres in Hidalgo for DR screening, causing overloading of these services. Furthermore, some interviewees said that the waiting time for an appointment is 4 to 8 months. Health authorities should consider using trained graders and fundus cameras in the second level eye health centres and any centre with a specific diabetic clinic, so that access to DR screening is available. The State of Hidalgo has a health brigade outreach to rural communities which includes fundus examinations in patients with DM. However, these brigades do not have a standardised plan and usually visit a community only once a year.

c) Limited treatment facilities.

When considering treatment services for DR it Is important to understand the geo-economic situation of the State of Hidalgo. Half (50.6%) of the population live in poverty, and 8% in extreme poverty,[217] with a high degree of social backwardness.[218] Three quarters of the health centres are in rural areas.[189] Much of the state is mountainous known as the *Sierra Madre Oriental* (Eastern Highlands in English). This picture is important to understand equity and access to services for DM / DR.

The Pan American Association of Ophthalmologists recommends having one laser for every 250,000-500,000 inhabitants managed by trained personal.[187] Based on the current population of Hidalgo, this translates to 6-12 lasers and staff. However, Hidalgo only has one functional laser in the General Hospital of Pachuca. With respect to the capacity to offer intravitreal anti-VEGF injections, both the health centres offering specialised eye clinics had these elements in place. However, due to the COVID-19 pandemic, the eye health centre in Tulancingo closed in order to manage COVID-19 patients (this topic is detailed in the next section), so since March 2019, the State of Hidalgo has only one functioning

vision centre for over 2 million people, with the only functional laser in the State. This information does not take into account the capacity of the private sector, which is centralised in the city of Pachuca and Mexico City.

The slow referral system and the limited capacity of the Pachuca eye health centre would suggest for those patients who can afford it management of DR is in private clinics; however, given the percentage of people living in poverty and the geographical barriers, it is likely that a large proportion of patients with DR do not have access to specialized treatment, resulting in blindness and disability, which exacerbates their poverty.[219]

d) Data on services

The national system of the General Direction of Health Information reports the number of ophthalmological consultations by eye care centres, but does not itemise DR as a specific diagnostic category.[154] Nor is there reporting of the number of fundus examinations performed in primary health centres, the number of patients who received anti-VEGF injections or pan-photocoagulation.

Section 6 describes the recommendations arising from the analysis of this work.

4.4. Impact of the COVID-19 pandemic on the provision of DM/DR services

Risk factors for Diabetes and COVID severity

As of April 2021, Mexico has reported nearly 2.5 million cases and 211,693 deaths due to COVID. Diabetics represent 13.3% of all cases and 37.3% of deaths.[80]

The DM-COVID relationship is bidirectional. On the one hand, DM is one of the risk factors for severe COVID and COVID mortality, as are obesity and hypertension.[75,92,94,95,220,221] On the other hand, different studies have identified that COVID can lead to a new onset of DM and an exacerbation of metabolic complications of pre-existing DM such as ketoacidosis.[222]

The SARS-COV-2 virus binds to ACE2 receptors, which are expressed on pancreatic beta cells, adipose tissue, and other organs, however, it is probable that development of new DM is related to the induction of autoimmune processes still under study. [159,222–225] There is currently no consensus on the pathways in which DM can be generated *de novo* or the duration of this effect, however, it is important to screen for DM in people with COVID and focus on the proper metabolic control of these patients.

The COVID pandemic offers an advocacy opportunity to persuade National and State health policy makers to update guidelines for screening of obesity, hypertension, and DM in the Mexican population as part of efforts to reduce COVID severity and mortality.

Impact of COVID on routine services for PLWD

The COVID pandemic has disrupted routine health services for NCDs worldwide. A WHO survey carried out in 163 countries, reported that 49% of countries had partially or totally suspended health care services for PLWD.[97] Although there is no metric for Mexico, some interviewees in this work said that in their experience, ~40% of the capacity to care for NCDs in primary care centres in Hidalgo has been lost during 2020 due to the pandemic.

The disruption of health services has been caused by three factors. First, redeployment of health personnel; second reorganisation of physical space in primary health centres and hospitals; third diversion of health finances to COVID prevention and treatment.

According to interviewees, the situation in 2020 before health workers had access to COVID vaccination was that about 40% of health professionals had stopped providing care to routine patients because they themselves were at risk of severe COVID due to age, obesity, uncontrolled DM or

hypertension. Once health workers were vaccinated, some of them returned to work in primary health centres and hospitals, but it is not known what percentage have still not returned to work.

In Hidalgo, health authorities redistributed active health personnel to try to solve the lack of personnel in regions where there was a greater need. The staff that continued to work in the primary health centres were mainly managing patients with COVID and emergency treatment of other patients.

Practically all primary health centres found it necessary to divide the physical space into COVID and non-COVID areas, so that the physical capacity to provide routine care was reduced. Most second-level hospitals were transformed into providing care for COVID patients. The General Hospital of Tulancingo closed most of its services during the pandemic, including the eye health unit. At the time of this analysis, these services remain closed and interviewees do not know when they are expected to reopen. The number of severe COVID cases saturated the Hidalgo hospital system between July 2020 and March 2021.[226–229]

The pandemic has led not only to a reduction in human resources and physical space for routine patients e.g. with DM / DR, but according to interviewees, it also resulted in financial resources for NCDs programmes and other routine health services being diverted to the pandemic to purchase biosafety equipment, medicines, diagnostic tests, hospital equipment and supplies such as oxygen and respirators.

It is possible to estimate the effects of this disruption on DM and DR services from available statistical reports. Table 33. The number of consultations in primary health centres for PLWD in Mexico decreased by 34.7% during the period May 2020 to March 2021, compared to the months prior to the pandemic. For Hidalgo the decrease in consultations was 21.3%, with a decrease in the number of consultations of more than 3,000 consultations per month in January and February 2021, when COVID was at its peak (Figure 12). There was also a decrease in ophthalmological consultations in the only eye health centre operating in Hidalgo during 2020; between April and May 2020 there were less than 50 eye consultations in the whole month, compared to more than 500 consultations in January 2020. According to interviewees, this situation was due to hospitals being used for COVID. Even until now, there has been no strategy to move these specialised eye services to another location in order to provide necessary care for patients with DR. A solution offered by interviewees is to create partnerships with the private sector so that DR patients can receive their care in private facilities with financial support from the State. Although this strategy was proposed to the Hidalgo authorities, it was not approved possibly due to the lack of financial resources.

Faced with lack of specialised care several respondents proposed expanding the MIDO programme so that primary health centres screen patients at risk of DM, and monitor the metabolic control (particularly glucose, weight, lipids and blood pressure measurements) of patients with DM/DR, offering each patient Individualised health promotion and preventive recommendations according to their measurements and medical background.

The pandemic has exposed the inadequacies of the health system and created severe new challenges to provide a continuum of care for PLWD and specialised care for those with DR. As the country emerges from the pandemic there is an opportunity to learn from this challenge and take steps to improve services going forward and to make the health system more resilient and effective.

4.5 Initial approach for scaling up diabetic eye care in Hidalgo

In order to address the challenge of visual loss from diabetic retinopathy in Hidalgo it is essential to increase the current workforce. This has two main components, to increase treatment services and improve the screening of people living with diabetes. Providing these services in Hidalgo can set an example for other states in Mexico to follow. The COVID-19 pandemic has shown the importance of constructing a resilient health service including eye care.

Based on the most recent DR clinical guidelines for Latin America,[187] there is a need to increase the laser treatment centres from the current 1 for over 2 million population to at least 4 in the next few years, and then based on demand a further increase can be considered. Together with the establishment of these laser treatment centres it will be necessary to train ophthalmologists in the treatment of DR, at least 1 and preferably 2 ophthalmologists for each treatment centre.

As the expansion of therapeutic capacity is put in place, it is also important to improve the capacity for screening and referral of those patients with DR. At present systematic screening is not feasible, however opportunistic screening can be carried out in primary health centres and outreach brigades by trained medical and non-medical personnel. For this, it is essential to have a well planned training programme in the use of direct ophthalmoscopes, until it is possible to introduce fundus cameras and train graders in DR.

Hidalgo has the advantage of having both physical and digital lists of diabetic patients, which provides the opportunity to actively contact this population for regular (annual) screening, as well as examining the eyes of patients who visit health centres for management of their diabetes. If good opportunistic screening of diabetic patients in health centres can be performed then it should be possible to reduce the burden on eye care services of having to see all diabetic patients for an eye examination.

Finally, the State needs to develop a new appointment system in the eye care centres in order to efficiently manage and treat those patients referred with DR who need expert evaluation and treatment.

These steps in training people to treat DR, screen for DR and improvement of the referral system can improve and transform the eye health service in the State.

5. CONCLUSIONS

The magnitude of DM and DR in Mexico.

Mexico with a population of approximately 126 million has 11 million people living with diabetes of which 3.7 million are expected to have diabetic retinopathy and 875 thousand require treatment for sight threatening retinopathy.

With the demographic change and the increase in the prevalence of DM, these figures are projected to increase by 2030 to 14 million people living with diabetes, of which 4.6 million and 1.4 million are expected to have DR and VTDR respectively.

The magnitude of DM and DR in Hidalgo.

Hidalgo with a population of approximately 3 million has 272,000 people living with diabetes of which 90,000 are expected to have DR and 21,000 require treatment for sight threatening retinopathy.

By 2030, approximately 344,000 people are estimated to have DM, of which, 120,000 will have DR and 34,000 VTDR.

The main constraints to the provision of DM / DR services in the public health system as identified using the TADDS tool.

- There is a limited public health education programme about diabetes mellitus.
- Primary health centres do not have all the required personnel, equipment and essential consumables / medicines for prevention, diagnosis and control of patients with DM.
- There is a limited health education of PLWD about eye complications specifically DR.
- Screening capacity for DR is very limited. There is as yet no clear strategy how to screen for DR as the sensitivity of direct fundoscopy is low compared to other strategies such as retinal photography by trained personnel, however fundus cameras and trained graders are not readily available.
- The specialist endocrinology and eye health services are only available in the State capital and are overloaded with cases.
- There is no effective referral system between primary health centres and specialist eye health centre.

The impact on health providers in the public sector in Hidalgo resulting from the COVID 19 epidemic in delivering services to persons living with DM / DR, and possible solutions.

The COVID-19 pandemic has reduced the health personnel and other resources available in primary health centres and secondary hospitals for DM/DR care.

- Some health professionals responsible for routine health services are now focusing on COVID-related issues (screening, medical management, vaccination programmes, etc.).
- Health personnel with risk factors for severe COVID (obesity, hypertension, DM, immunosuppression) were assigned to perform home-based activities.
- Some financial resources focused on routine health programmes such as NCDs were used for COVID care.
- The eye health area of the General Hospital in Tulancingo was closed due to the redistribution of space and activities, so that only the eye health centre of the General Hospital in Pachuca is the only one in operation.

Summary

This study has shown that DM is a national health priority, for which health promotion, preventive and therapeutic measures are inadequate.

Those DM and DR services that were present have been severely reduced by the COVID epidemic.

As the country emerges from COVID there is a need for a new national policy to promote healthy lifestyles and to provide screening and effective management for DM at the primary level of health care. The MIDO strategy can be a useful tool in this regard.

DR is not currently recognised as a priority in available health policies, or by operational clinical guidelines across the continuum of DM/DR care.

After analysing the current situation for DM / DR care in Hidalgo, this work discusses and proposes specific policy and implementation recommendations.

As requested by the Hidalgo health authorities, this work provides a policy brief based on the results of this study.

6. RECOMMENDATIONS

TO IMPROVE DM SERVICES IN MEXICO AND HIDALGO

National Level

1. Review and update the national norms and clinical guidelines for DM prevention, screening and management. It is recommended to standardise the period for reviewing and updating documents (e.g. at least every three years).
2. Publish on a national website the most recent guidelines (together with relevant evidence) for health professionals such as general practitioners, specialists, public health professionals, nurses, nutritionists, etc.
3. Create national health promotion guidelines and materials aimed at people at high risk of DM.

Hidalgo

4. Develop a plan to reduce morbidity and mortality from DM including health promotion, screening, diagnosis, glycaemic control and follow-up at primary health centres.
5. Ensure that all primary health centres in Hidalgo have access to the MIDO and MIDO Pregnancy digital health strategies with the respective supplies for screening and follow-up of NCDs in the adult population and pregnant women.
6. Ensure 100% supply of medicines for the care of DM in primary health centres in Hidalgo, regardless of whether their purchase is centralised from the federal government.
7. Provide a programme of continuing medical education for general practitioners including control of glucose, blood pressure and lipids, and the capacity to offer insulin management to patients with DM in primary health centres so that this population does not need to be referred to second-level health centres avoiding the delay in the treatment and control of patients.[34] A platform to carry out this continuing medical education strategy could be the *Aprende* portal of the Carlos Slim Foundation, which offers other training courses and certificates for health personnel at the national level.[230] This programme could start in Hidalgo and then scale up to other states using the learnings from Hidalgo.
8. Reopen the three closed UNEMEs in Hidalgo with the aim of improving services and waiting times for referrals to the UNEME unit currently in operation.
9. Health authorities should consider opening new UNEMEs in other regions of Hidalgo in order to reduce the geographical and economic barriers to specialised centres for people with DM/DR (NCDs).
10. Review the referral system between first and second level of care because the current system is slow and inefficient. One possibility is to explore the digitisation of the referral system where internet access allows.

TO IMPROVE DR SERVICES IN MEXICO AND HIDALGO

National Level

1. Develop national clinical guidelines for the management of DR, including screening, grading, treatment, and follow-up of people with DR.

Hidalgo

2. Create and publish operational guidelines for screening, grading, referral, management, follow-up, rehabilitation, and reporting of DR.
3. Strengthening capacity for treating patients with VTDR.
   In the short term (1-2 years): At present in Hidalgo there is only one equipment to perform pan-photocoagulation (lasers) in eye health centres, it is important to guarantee that at least 3-6 lasers

are operated by trained personnel in the State (considering 1 laser for every 250,000-500,000).[187] Also ensuring anti-VEGF treatments are also available in eye health centres.[231–234]

Medium and long term: Ideally, over 3-5 years obtain 6-12 lasers operated by trained staff, distributed throughout the State with the aim of reducing economic and geographic barriers and improving equity in access to treatment.[187,235]

4. Strengthen the capacity to screen PLWD for DR.
   a. **In the short term:** Start opportunistic screening, including: a) GPs having the ability to perform fundoscopy and test visual acuity when PLWD attend primary health centres, b) ensuring information for PLWD about the need to have an annual eye examination, and c) establish a timely referral programme to see an ophthalmologist at a eye health centres.
   b. **Medium - Long term:** Consider moving towards a systematic screening programme when treatment facilities are available. For this, it is important to consider the following points:[187]
      - There should be well-established clinical and operational guidelines for the management of DR in Hidalgo.
      - An appropriate screening method must be chosen based on the financial and operational capacity of the State.
      - Trained personnel must be available to carry out the selected screening strategies.
      - Consider the sustainability / cost of this programme in the long term.
5. Provide health promotion materials for diabetics about the risk of developing DR. (Given that 70% of diabetics in Hidalgo also have dyslipidaemia, hypertension or metabolic syndrome,[116] it is important to target this population with health promotion about metabolic control of these conditions.)
6. Develop a good data collection and reporting system of the indicators of interest, including:
   - Number of screenings (positive and negative)
   - Number diagnosed with DR and VTDR
   - Number treated with laser and visual outcome
   - Number treated with anti-VEGF and visual outcome

RECOMMENDATIONS ABOUT DM/DR SERVICES IN A PANDEMIC

1. Ensure that Primary Health Centres and hospitals that care for DM have non-COVID care areas and keep the necessary biosecurity elements for the protection of health personnel and patients.
2. Ensure there is the minimum number of health personnel necessary to provide quality care so as not to interrupt the care of people with DM in primary health centres and persons with DR in secondary level hospitals.
3. If a physical space in a health centre of a hospital is to be used for the care of COVID patients, it is recommended to explore options for the transfer of DM and DR care services to other places so that DM and DR care is not disrupted.
4. Ensure that eye health centres are located in non-COVID care areas and keep the necessary biosecurity elements for the protection of health personnel and patients.

7. REFERENCES

1 World Health Organization. Global Report on Diabetes. *Isbn* 2016; **978**: 88.

2 International Diabetes Federation. IDF Diabetes Atlas 2019. 2019 http://www.idf.org/about-diabetes/facts-figures (accessed March 5, 2020).

3 Abbafati C, Machado DB, Cislaghi B, *et al.* Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet* 2020; **396**: 1204–22.

4 Lin X, Xu Y, Pan X, *et al.* Global, regional, and national burden and trend of diabetes in 195 countries and territories: an analysis from 1990 to 2025. *Sci Rep* 2020; **10**: 14790.

5 GBD Results Tool | GHDx. http://ghdx.healthdata.org/gbd-results-tool (accessed April 24, 2021).

6 American Diabetes Association. 2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes—2021. *Diabetes Care* 2021; **44**: S15–33.

7 J. Larry Jameson, Anthony S. Fauci, Dennis L. Kasper, Stephen L. Hauser, Dan L. Longo JL. Harrison's Principles of Internal Medicine, 20th edn. New York: McGraw-Hill, 2018.

8 American Diabetes Association. 14. Management of Diabetes in Pregnancy: Standards of Medical Care in Diabetes—2021. *Diabetes Care* 2021; **44**: S200–10.

9 International Diabetes Federation - Type 2 diabetes. https://www.idf.org/aboutdiabetes/type-2-diabetes.html (accessed March 4, 2020).

10 Clark NG, Fox KM, Grandy S. Symptoms of diabetes and their association with the risk and presence of diabetes: Findings from the study to help improve early evaluation and management of risk factors leading to diabetes (SHIELD). *Diabetes Care* 2007; **30**: 2868–73.

11 Diagnosis | ADA. https://www.diabetes.org/a1c/diagnosis (accessed March 27, 2021).

12 Saeedi P, Petersohn I, Salpea P, *et al.* Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas, 9th edition. *Diabetes Res Clin Pract* 2019; **157**. DOI:10.1016/j.diabres.2019.107843.

13 American Diabetes Association. 2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes-2020. Diabetes Care. 2020; **43**: S14–31.

14 Diabetes Prevention Program (DPP) Research Group. The Diabetes Prevention Program (DPP): description of lifestyle intervention. *Diabetes Care* 2002; **25**: 2165–71.

15 Thorp AA, Kingwell BA, Sethi P, Hammond L, Owen N, Dunstan DW. Alternating bouts of sitting and standing attenuate postprandial glucose responses. *Med Sci Sports Exerc* 2014; **46**: 2053–61.

16 Fedewa M V., Gist NH, Evans EM, Dishman RK. Exercise and insulin resistance in youth: A meta-analysis. *Pediatrics* 2014; **133**. DOI:10.1542/peds.2013-2718.

17 Hsin-Chieh Yeh, PhD; Bruce B. Duncan, MD, PhD; Maria Ineˆs Schmidt, PhD; Nae-Yuh Wang, PhD; and Frederick L. Brancati, MD M. Smoking, Smoking Cessation, and Risk for Type 2 Diabetes Mellitus. *Ann Intern Med* 2013; **152**: 10–7.

18 Association AD. 9. Pharmacologic Approaches to Glycemic Treatment: Standards of Medical

Care in Diabetes—2021. *Diabetes Care* 2021; **44**: S111–24.

19 American Diabetes Association. 6. Glycemic Targets: Standards of Medical Care in Diabetes—2021. *Diabetes Care* 2021; **44**: S73–84.

20 Pasquier F. Diabetes and cognitive impairment: How to evaluate the cognitive status? *Diabetes Metab* 2010; **36**: S100–5.

21 Shlomo Melmed Ronald Koenig Clifford Rosen Richard Auchus Allison Goldfine. 37. Complications of Diabetes Mellitus, In: Williams Textbook of Endocrinology -, 14th edn. Elsevier, 2019.

22 ENSANUT 2012. Diabetes mellitus: la urgencia de reforzar la respuesta en políticas públicas para su prevención y control. Cuernavaca, Morelos (Mexico), 2012 https://ensanut.insp.mx/encuestas/ensanut2012/doctos/analiticos/DiabetesMellitus.pdf (accessed Feb 6, 2021).

23 Barcelo A, Arredondo A, Gordillo-Tobar A, Segovia J, Qiang A. The cost of diabetes in Latin America and the Caribbean in 2015: Evidence for decision and policy makers. *J Glob Health* 2017; **7**. DOI:10.7189/jogh.07.020410.

24 Huru JM, Leiviskä I, Saarela V, Liinamaa MJ. Prediabetes influences the structure of the macula: Thinning of the macula in the Northern Finland Birth Cohort. *Br J Ophthalmol* 2020; published online Oct 7. DOI:10.1136/bjophthalmol-2020-317414.

25 Ikram MK, Janssen JAMJL, Roos AME, *et al.* Retinal vessel diameters and risk of impaired fasting glucose or diabetes: The Rotterdam Study. *Diabetes* 2006; **55**: 506–10.

26 Cheung N, Mitchell P, Wong TY. Diabetic retinopathy. In: The Lancet. Elsevier B.V., 2010: 124–36.

27 American Diabetes Association - Standards of Medical Care in Diabetes - 2020. *Diabetes Care* 2020; **43**.

28 ICO Guidelines for Diabetic Eye Care. 2017 www.icoph.org/downloads/icoethicalcode.pdf (accessed March 4, 2020).

29 Community Eye Health Journal » Diabetic retinopathy (DR): management and referral. https://www.cehjournal.org/article/diabetic-retinopathy-dr-management-and-referral-2/ (accessed March 10, 2020).

30 Yau JWY, Rogers SL, Kawasaki R, *et al.* Global prevalence and major risk factors of diabetic retinopathy. *Diabetes Care* 2012; **35**: 556–64.

31 Zheng Y, He M, Congdon N. The worldwide epidemic of diabetic retinopathy. *Indian J Ophthalmol* 2012; **60**: 428–31.

32 Teo ZL, Tham Y-C, Yu M, *et al.* Global Prevalence of Diabetic Retinopathy and Projection of Burden through 2045: Systematic Review and Meta-analysis. *Ophthalmology* 2021; **0**. DOI:10.1016/J.OPHTHA.2021.04.027.

33 Omae T, Nagaoka T, Yoshida A. Effects of habitual cigarette smoking on retinal circulation in patients with type 2 diabetes. *Investig Ophthalmol Vis Sci* 2016; **57**: 1345–51.

34 Younis N, Broadbent DM, Vora JP, Harding SP. Incidence of sight-threatening retinopathy in patients with type 2 diabetes in the Liverpool Diabetic Eye Study: A cohort study. *Lancet* 2003; **361**: 195–200.

35 King P, Peacock I, Donnelly R. The UK Prospective Diabetes Study (UKPDS): clinical and therapeutic implications for type 2 diabetes. *Br J Clin Pharmacol* 1999; : 1–6.

36 European Conference On Screening For Diabetic Retinopathy. http://www.drscreening2005.org.uk/ (accessed March 5, 2020).

37 Nishantha Piyasena MMP, Murthy GVS, Yip JLY, *et al.* Systematic review on barriers and enablers for access to diabetic retinopathy screening services in different income settings. *PLoS One* 2019; **14**: e0198979.

38 Screening for Diabetic Retinopathy - 2014 - American Academy of Ophthalmology. https://www.aao.org/clinical-statement/screening-diabetic-retinopathy (accessed April 21, 2020).

39 James M, Turner DA, Broadbent DM, Vora J, Harding SP. Cost effectiveness analysis of screening for sight threatening diabetic eye disease. *Br Med J* 2000; **320**: 1627–31.

40 Institute for Health Metrics and Evaluation. Mexico | Institute for Health Metrics and Evaluation. 2020. http://www.healthdata.org/mexico?language=149 (accessed Aug 23, 2021).

41 Mexico Population 2021 (Demographics, Maps, Graphs). https://worldpopulationreview.com/countries/mexico-population (accessed Sept 4, 2021).

42 Instituto Nacional de Estadística y Geografía (INEGI). https://www.inegi.org.mx/ (accessed Feb 15, 2020).

43 Mexico Location. https://en.wikipedia.org/wiki/File:MEX_orthographic.svg (accessed April 16, 2021).

44 Political division of Mexico. https://en.wikipedia.org/wiki/File:Division_politica_mexico.svg (accessed April 16, 2021).

45 Gómez Dantés O, Sesma S, Arreola H, Frenk J. Sistema de salud de México. *Salud Pública de Mézico* 2011; **53**: s220–32.

46 INEGI. Derechohabiencia. 2021. https://inegi.org.mx/temas/derechohabiencia/ (accessed April 30, 2021).

47 Normas Oficiales Mexicanas | Secretaría de Salud | Gobierno | gob.mx. 2015; published online Aug 15. https://www.gob.mx/salud/en/documentos/normas-oficiales-mexicanas-9705 (accessed March 16, 2021).

48 NORMA Oficial Mexicana NOM-015-SSA2-2010, Para la prevención, tratamiento y control de la diabetes mellitus. http://www.dof.gob.mx/normasOficiales/4215/salud/salud.htm (accessed March 7, 2020).

49 CENETEC. GUÍA DE PRÁCTICA CLÍNICA GPC Tratamiento de la DIABETES MELLITUS TIPO 2 en el primer nivel de atención. 2018.

50 CENETEC. GUÍA DE PRÁCTICA CLÍNICA GPC Diagnóstico y tratamiento de RETINOPATÍA DIABÉTICA. Ciudad de México, 2015 GUÍA DE PRÁCTICA CLÍNICA GPC Diagnóstico y tratamiento de RETINOPATÍA DIABÉTICA. (accessed March 7, 2020).

51 CENETEC. GUÍA DE PRÁCTICA CLÍNICAG PC PACIENTE CON DIABETES MELLITUS. Cuidad de Mexico, 2015 http://www.cenetec.salud.gob.mx/interior/catalogoMaestroGPC.html (accessed March 16, 2021).

52 CENETEC. GUÍA DE PRÁCTICA CLÍNICA GPC Detección de RETINOPATÍA DIABÉTICA en Primer Nivel de Atención Evidencias y Recomendaciones Catálogo Maestro de Guías de Práctica Clínica: IMSS-735-14. http://www.cenetec.salud.gob.mx/interior/catalogoMaestroGPC.html (accessed March 7, 2020).

53 Resnikoff S, Lansingh VC, Washburn L, *et al.* Estimated number of ophthalmologists worldwide (International Council of Ophthalmology update): will we meet the needs? *Br J Ophthalmol* 2020; **104**: 588–92.

54 International Council of Ophthalmology : Ophthalmologists Worldwide. http://www.icoph.org/ophthalmologists-worldwide.html (accessed Sept 4, 2021).

55 Consejo Mexicano de Oftalmología, A.C.®. https://www.cmoftalmologia.org/ (accessed Sept 4, 2021).

56 Community Eye Health Journal » Improving access to refractive and eye health services. https://www.cehjournal.org/article/improving-access-to-refractive-and-eye-health-services/ (accessed April 12, 2020).

57 Shneor E, Isaacson M, Gordon-Shaag A. The number of optometrists is inversely correlated with blindness in OECD countries. *Ophthalmic Physiol Opt* 2021; **41**: 198–201.

58 Shamah-Levy T, Vielma-Orozco E, Heredia-Hernández O, Romero-Martínez M, Mojica-Cuevas J C-NL, Santaella-Castell JA R-DJE. Encuesta Nacional de Salud y Nutrición 2018. Cuernavaca, Morelos, 2020 https://ensanut.insp.mx/encuestas/ensanut2018/informes.php (accessed Feb 1, 2021).

59 INEGI. Población total por entidad federativa y grupo quinquenal de edad según sexo, 1990 a 2020. 2021. https://www.inegi.org.mx/app/tabulados/interactivos/?pxq=Poblacion_Poblacion_01_e60cd8cf-927f-4b94-823e-972457a12d4b (accessed March 7, 2021).

60 Resumen. Hidalgo. http://cuentame.inegi.org.mx/monografias/informacion/hgo/ (accessed March 7, 2020).

61 INEGI. Población 2015. https://www.inegi.org.mx/temas/estructura/ (accessed March 4, 2020).

62 File:Hidalgo in Mexico (zoom).svg - Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Hidalgo_in_Mexico_(zoom).svg (accessed March 7, 2020).

63 File:Blank map of Hidalgo.svg - Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Blank_map_of_Hidalgo.svg (accessed March 7, 2020).

64 Lourdes Cristina C-A, Canales Flor Lizbeth N, Torres Moisés O, *et al.* Effectiveness in the Implementation of a Sectorial Diabetic Retinopathy Prevention Program in Hidalgo. 2017.

65 World Health Organization. Situational Report 82: Coronavirus disease 2019 (COVID-19). 2020; : 1–13.

66 Guan W, Ni Z, Hu Y, *et al.* Clinical Characteristics of Coronavirus Disease 2019 in China. *N Engl J Med* 2020; **382**: 1708–20.

67 Tang JW, Marr LC, Li Y, Dancer SJ. Covid-19 has redefined airborne transmission. *BMJ* 2021; **373**: n913.

68 Murray CJL, Piot P. The Potential Future of the COVID-19 Pandemic: Will SARS-CoV-2 Become a Recurrent Seasonal Infection? JAMA - J. Am. Med. Assoc. 2021; **325**: E1–2.

69 Yanes-Lane M, Winters N, Fregonese F, *et al.* Proportion of asymptomatic infection among COVID-19 positive persons and their transmission potential: A systematic review and meta-analysis. *PLoS One* 2020; **15**. DOI:10.1371/journal.pone.0241536.

70 He J, Guo Y, Mao R, Zhang J. Proportion of asymptomatic coronavirus disease 2019: A systematic review and meta-analysis. *J Med Virol* 2021; **93**: 820–30.

71 Grant MC, Geoghegan L, Arbyn M, *et al.* The prevalence of symptoms in 24,410 adults infected by the novel coronavirus (SARS-CoV-2; COVID-19): A systematic review and meta-analysis of 148 studies from 9 countries. *PLoS One* 2020; **15**: e0234765.

72 Mizrahi B, Shilo S, Rossman H, *et al.* Longitudinal symptom dynamics of COVID-19 infection. *Nat Commun* 2020; **11**: 1–10.

73 Home - Johns Hopkins Coronavirus Resource Center. https://coronavirus.jhu.edu/ (accessed April 17, 2021).

74 Mortality Risk of COVID-19 - Statistics and Research - Our World in Data. https://ourworldindata.org/mortality-risk-covid (accessed April 17, 2021).

75 Berumen J, Schmulson M, Alegre-Díaz J, *et al.* Risk of infection and hospitalization by Covid-19 in Mexico: A case-control study. medRxiv. 2020; : 2020.05.24.20104414.

76 Huang C, Huang L, Wang Y, *et al.* 6-month consequences of COVID-19 in patients discharged from hospital: a cohort study. *Lancet* 2021; **397**: 220–32.

77 Sudre CH, Murray B, Varsavsky T, *et al.* Attributes and predictors of long COVID. *Nat Med* 2021; **27**: 626–31.

78 COVID-19 tracker. https://vac-lshtm.shinyapps.io/ncov_tracker/ (accessed April 17, 2021).

79 WHO Coronavirus (COVID-19) Dashboard | WHO Coronavirus (COVID-19) Dashboard With Vaccination Data. https://covid19.who.int/ (accessed April 17, 2021).

80 COVID-19 Tablero México - CONACYT - CentroGeo - GeoInt - DataLab. https://datos.covid-19.conacyt.mx/ (accessed April 17, 2021).

81 Principles of Epidemiology | Lesson 3 - Section 3. https://www.cdc.gov/csels/dsepd/ss1978/lesson3/section3.html (accessed April 17, 2021).

82 Case fatality rate of COVID-19 vs. Median age of the population. https://ourworldindata.org/grapher/case-fatality-rate-of-covid-19-vs-median-age?tab=table&country=~MEX (accessed April 17, 2021).

83 Karlinsky A, Kobak D. The World Mortality Dataset: Tracking excess mortality across countries during the COVID-19 pandemic. *medRxiv Prepr Serv Heal Sci* 2021; published online June 4. DOI:10.1101/2021.01.27.21250604.

84 Mexico's Response to Covid-19: A Case Study | Global Health Sciences. https://globalhealthsciences.ucsf.edu/news/mexicos-response-covid-19-case-study (accessed April 17, 2021).

85 Huang I, Lim MA, Pranata R. Diabetes mellitus is associated with increased mortality and severity of disease in COVID-19 pneumonia – A systematic review, meta-analysis, and meta-regression: Diabetes and COVID-19. *Diabetes Metab Syndr Clin Res Rev* 2020; **14**: 395–403.

86 Zhu L, She ZG, Cheng X, *et al.* Association of Blood Glucose Control and Outcomes in Patients with COVID-19 and Pre-existing Type 2 Diabetes. *Cell Metab* 2020; **31**: 1068-1077.e3.

87 Petrilli CM, Jones SA, Yang J, *et al.* Factors associated with hospital admission and critical illness among 5279 people with coronavirus disease 2019 in New York City: Prospective cohort study. *BMJ* 2020; **369**. DOI:10.1136/bmj.m1966.

88 Zhou F, Yu T, Du R, *et al.* Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *Lancet* 2020; **395**: 1054–62.

89 Li B, Yang J, Zhao F, *et al.* Prevalence and impact of cardiovascular metabolic diseases on COVID-19 in China. Clin. Res. Cardiol. 2020; **109**: 531–8.

90 Guo L, Shi Z, Zhang Y, *et al.* Comorbid diabetes and the risk of disease severity or death among 8807 COVID-19 patients in China: A meta-analysis. *Diabetes Res Clin Pract* 2020; **166**: 108346.

91 Shi Q, Zhang X, Jiang F, *et al.* Clinical Characteristics and Risk Factors for Mortality of COVID-19 Patients with Diabetes in Wuhan, China: A Two-Center, Retrospective Study. *Diabetes Care* 2020; **43**: 1382–91.

92 Holman N, Knighton P, Kar P, *et al.* Risk factors for COVID-19-related mortality in people with type 1 and type 2 diabetes in England: a population-based cohort study. *Lancet Diabetes Endocrinol* 2020; **8**: 823–33.

93 Degarege A, Naveed Z, Kabayundo J, Brett-Major D. Risk factors for severe illness and death in COVID-19: A systematic review and meta-analysis. medRxiv. 2020; : 2020.12.03.20243659.

94 Apicella M, Campopiano MC, Mantuano M, Mazoni L, Coppelli A, Del Prato S. COVID-19 in people with diabetes: understanding the reasons for worse outcomes. Lancet Diabetes Endocrinol. 2020; **8**: 782–92.

95 Dhurandhar N V., Akheruzzaman M, Hegde V. Potentially modifiable factors to reduce severity of COVID-19 in type 2 diabetes. Nutr. Diabetes. 2020; **10**: 1–3.

96 Curfman G. Renin-Angiotensin-Aldosterone Inhibitors and Susceptibility to and Severity of COVID-19. JAMA - J. Am. Med. Assoc. 2020; **324**: 177–8.

97 WHO. Noncommunicable diseases and COVID-19. 2020; published online Sept 3. https://www.who.int/teams/noncommunicable-diseases/covid-19 (accessed March 20, 2021).

98 Hidalgo | Consejo Mexicano de Oftalmología. https://www.cmoftalmologia.org/hidalgo/ (accessed March 4, 2020).

99 Cristina Carrillo-Alarcón L, Norato Canales L, Leticia Chagoya Solís M, Ocampo Torres M, Pablo Vargas-Carrillo J, de Dios Álvarez J. IMPACT ON TREATMENT ADHERENCE USING PHARMACOTHERAPY CONSULTATION IN PATIENTS WITH TYPE 2 DIABETES MELLITUS AND HYPERTENSION IN RURAL AND URBAN POPULATION OF HIDALGO, MEXICO. *Lourdes al World J Pharm Res World J Pharm Res SJIF Impact Factor* 2018; **7**: 47–59.

100 Carrillo-Alarcón LC, López-López E, López-Carbajal MJ, *et al.* Level of Knowledge in Patients with Type 2 Diabetes Mellitus and its Relationship with Glycemic Levels and Stages of Grief According to Kübler-Ross. *J Diabetes Metab* 2015; **6**: 495.

101 Çaparlar CÖ, Dönmez A. What is scientific research and how can it be done? Turk Anesteziyoloji ve Reanimasyon Dern. Derg. 2016; **44**: 212–8.

102 Varpio L, Macleod A. Philosophy of Science Series: Harnessing the Multidisciplinary Edge Effect by Exploring Paradigms, Ontologies, Epistemologies, Axiologies, and Methodologies. Acad. Med. 2020; **95**: 686–9.

103 Park YS, Konge L, Artino AR. The Positivism Paradigm of Research. Acad. Med. 2020; **95**: 690–4.

104 BMR. Pragmatism Research Philosophy - Research-Methodology. https://research-methodology.net/research-philosophy/pragmatism-research-philosophy/ (accessed May 22, 2021).

105 Steven Tenny, Grace D. Brannan, Janelle M. Brannan, Nancy C. Sharts-Hopko. Qualitative Study - StatPearls. StatPearls Publishing, 2020 https://www.ncbi.nlm.nih.gov/books/NBK470395/ (accessed May 22, 2021).

106 Crotty M. The Foundations of Social Research: Meaning and Perspective in the Research Process. London, UK: SAGE Publications, 1998.

107 MACKENZIE JIM. Positivism and Constructivism, Truth and 'Truth'. *Educ Philos Theory* 2011; **43**: 534–46.

108 Green J, Thorogood N. Qualitative Methods for Health Research, 2nd Editio. London, UK: SAGE Publications, 2012 https://books.google.com.mx/books?id=CnNEAgAAQBAJ.

109 De Allegri M, Sieleunou I, Abiiro GA, Ridde V. How far is mixed methods research in the field of health policy and systems in Africa? A scoping review. Health Policy Plan. 2018; **33**: 445–55.

110 Curry LA, Krumholz HM, O'Cathain A, Clark VLP, Cherlin E, Bradley EH. Mixed methods in biomedical and health services research. *Circ Cardiovasc Qual Outcomes* 2013; **6**: 119–23.

111 Igumbor JO, Bosire EN, Karimi F, *et al.* Global Public Health Effective supervision of doctoral students in public and population health in Africa: CARTA supervisors' experiences, challenges and perceived opportunities. 2021. DOI:10.1080/17441692.2020.1864752.

112 Schoonenboom J, Johnson RB. Wie man ein Mixed Methods-Forschungs-Design konstruiert. *Kolner Z Soz Sozpsychol* 2017; **69**: 107–31.

113 Black K. Business Statistics: Contemporary Decision Making, 6th Editio. John Wiley & Sons, Ltd, 2010.

114 Ames H, Glenton C, Lewin S. Purposive sampling in a qualitative evidence synthesis: A worked example from a synthesis on parental perceptions of vaccination communication. *BMC Med Res Methodol* 2019; **19**: 1–9.

115 Centro Nacional de Programas Preventivos y Control de Enfermedades | Gobierno | gob.mx. https://www.gob.mx/salud/cenaprece (accessed Feb 15, 2020).

116 Tablero de Control de Enfermedades Crónicas. http://www.tablerocronicas.info/DirApp/tableros/OSICDetDM2.aspx (accessed Feb 8, 2020).

117 Shamah-Levy T V-OE, Santaella-Castell JA R-DJ. Encuesta Nacional de Salud y Nutrición 2018-19: Resultados Nacionales. Cuernavaca, Morelos (Mexico), 2020.

118 Consejo Nacional de Población | Gobierno | gob.mx. https://www.gob.mx/conapo (accessed Feb 15, 2020).

119 CONEVAL Consejo Nacional de Evaluación de la Política de Desarrollo Social | CONEVAL.

https://www.coneval.org.mx/Paginas/principal.aspx (accessed Feb 15, 2020).

120 RAAB Repository. http://raabdata.info/ (accessed Feb 15, 2020).

121 DR Barometer - Shifting the needle. https://drbarometer.com/ (accessed Feb 15, 2020).

122 Global Burden of Disease Study 2019 (GBD 2019) Data Resources | GHDx. http://ghdx.healthdata.org/gbd-2019 (accessed Jan 31, 2021).

123 Global Burden of Disease Study 2016 (GBD 2016) Disability Weights | GHDx. http://ghdx.healthdata.org/record/ihme-data/gbd-2016-disability-weights (accessed Feb 15, 2020).

124 Vos T, Lim SS, Abbafati C, *et al.* Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet* 2020; **396**: 1204–22.

125 Tool for the assessment of diabetic retinopathy and diabetes management systems. 2015 www.who.int (accessed Feb 15, 2020).

126 MONITORING THE BUILDING BLOCKS OF HEALTH SYSTEMS: A HANDBOOK OF INDICATORS AND THEIR MEASUREMENT STRATEGIES. 2010 www.iniscommunication.com (accessed April 12, 2020).

127 Mishra SK, Jha N, Shankar PR, Dahal PK, Khatiwada B, Sapkota YD. An Assessment of Diabetic Retinopathy and Diabetes Management System in Nepal. *J Nepal Health Res Counc* 2016; **14**: 104–10.

128 M. K, M. K, S.P. M, *et al.* A stakeholder perspective on diabetes mellitus and diabetic retinopathy care in Iran; A qualitative study. *Arch Iran Med* 2017; **20**: 288–94.

129 REDCap. https://www.project-redcap.org/ (accessed Jan 17, 2020).

130 LSHTM. LSHTM Data Storage Options. https://www.lshtm.ac.uk/files/LSHTM-data-storage-options.pdf (accessed Feb 15, 2020).

131 Video Conferencing, Web Conferencing, Online Meetings, Screen Sharing - Zoom. https://lshtm.zoom.us/ (accessed May 9, 2021).

132 Boyatzis RE. Transforming Qualitative Information: Thematic Analysis and Code Development. London, UK: SAGE Publications, 1998 https://books.google.com.gi/books?id=%5C_rfClWRhIKAC.

133 Nowell LS, Norris JM, White DE, Moules NJ. Thematic Analysis: Striving to Meet the Trustworthiness Criteria. *Int J Qual Methods* 2017; **16**. DOI:10.1177/1609406917733847.

134 Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol* 2006; **3**: 77–101.

135 Charmaz K. Constructing Grounded Theory: A Practical Guide Through Qualitative Analysis. London, UK: SAGE Publications, 2006.

136 Holloway I, Todres L. The Status of Method: Flexibility, Consistency and Coherence. *Qual Res* 2003; **3**: 345–57.

137 Transcription Software to Convert Audio to Text | Transcribe. https://transcribe.wreally.com/ (accessed May 9, 2021).

138 Bazeley, Pat & Jackson K. Qualitative Data Analysis with NVivo, 2nd Editio. London: SAGE Publications Ltd, 2013.

139 Ltd QIP. NVivo qualitative data analysis software. 2018. https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/home.

140 Eisenhardt KM. Building Theories from Case Study Research. *Acad Manag Rev* 1989; **14**: 532.

141 International Q. NVivo 10 for Windows Help. About Nodes. https://help-nv10.qsrinternational.com/desktop/concepts/about_nodes.htm (accessed Jan 9, 2021).

142 LSHTM. Good Research Practice Policy 2019-2021. Report. 2019; : 1–21.

143 Dwyer SC, Buckle JL. The Space Between: On Being an Insider-Outsider in Qualitative Research. *Int J Qual Methods* 2009; **8**: 54–63.

144 Merriam SB, Johnson-Bailey J, Lee MY, Kee Y, Ntseane G, Muhamad M. Power and positionality: Negotiating insider/outsider status within and across cultures. *Int J Lifelong Educ* 2001; **20**: 405–16.

145 Cohen D, Crabtree B. RWJF - Qualitative Research Guidelines Project | Mays & Pope | Mays and Pope's Evaluative Criteria. 2006. http://www.qualres.org/HomeMays-3678.html (accessed May 24, 2021).

146 Carter N, Bryant-Lukosius D, Dicenso A, Blythe J, Neville AJ. The use of triangulation in qualitative research. Oncol. Nurs. Forum. 2014; **41**: 545–7.

147 INEGI. Población total por entidad federativa y grupo quinquenal de edad según sexo, 1990 a 2020. 2020. https://www.inegi.org.mx/app/tabulados/interactivos/?pxq=Poblacion_Poblacion_01_e60cd8cf-927f-4b94-823e-972457a12d4b (accessed Jan 30, 2021).

148 Datos Abiertos de México - Proyecciones de la Población de México y de las Entidades Federativas, 2016-2050. https://datos.gob.mx/busca/dataset/proyecciones-de-la-poblacion-de-mexico-y-de-las-entidades-federativas-2016-2050 (accessed Feb 1, 2021).

149 Polack S, Yorston D, López-Ramos A, *et al.* Rapid Assessment of Avoidable Blindness and Diabetic Retinopathy in Chiapas, Mexico. *Ophthalmology* 2012; **119**: 1033–40.

150 Indicadores Demográficos de México de 1950 a 2050. http://www.conapo.gob.mx/work/models/CONAPO/Mapa_Ind_Dem18/index_2.html (accessed Sept 19, 2021).

151 Número de habitantes. Cuéntame de México. http://www.cuentame.inegi.org.mx/poblacion/habitantes.aspx?tema=P (accessed Sept 19, 2021).

152 Encuesta Intercensal 2015. https://www.inegi.org.mx/programas/intercensal/2015/#Tabulados (accessed Sept 19, 2021).

153 CONAPO. Mapa de Indicadores Demográficos. CONAPO. 2018. http://www.conapo.gob.mx/work/models/CONAPO/Mapa_Ind_Dem/index_2.html (accessed Oct 6, 2018).

154 DGIS. Servicios SIS. 2021. http://www.dgis.salud.gob.mx/contenidos/basesdedatos/bdc_serviciossis_gobmx.html (accessed June 15, 2021).

155 Knaul FM, González-Pier E, Gómez-Dantés O, *et al.* The quest for universal health coverage: Achieving social protection for all in Mexico. Lancet. 2012; **380**: 1259–79.

156 Frenk J, Gómez-Dantés O, Knaul FM. The democratization of health in Mexico: Financial innovations for universal coverage. Bull. World Health Organ. 2009; **87**: 542–8.

157 Compra de medicinas se retrasa ahora por revisión a empresas. https://www.animalpolitico.com/2021/04/medicinas-compra-retraso-abasto-empresas/ (accessed June 26, 2021).

158 Ante desabasto de medicamentos que afecta a pacientes, urge fortalecer el sistema de compra consolidada que encabezan INSABI y UNOPS – COPARMEX. https://coparmex.org.mx/ante-desabasto-de-medicamentos-que-afecta-a-pacientes-urge-fortalecer-el-sistema-de-compra-consolidada-que-encabezan-insabi-y-unops/ (accessed June 26, 2021).

159 Rubino F, Amiel SA, Zimmet P, *et al.* New-Onset Diabetes in Covid-19. *N Engl J Med* 2020; **383**: 789–90.

160 Tsimihodimos V, Gonzalez-Villalpando C, Meigs JB, Ferrannini E. Hypertension and Diabetes Mellitus Coprediction and Time Trajectories. *Hypertension* 2018; **71**: 422–8.

161 Montefusco L, Ben Nasr M, D'Addio F, *et al.* Acute and long-term disruption of glycometabolic control after SARS-CoV-2 infection. *Nat Metab 2021 36* 2021; **3**: 774–85.

162 Tablero MIDO Web. http://www.mido-global.com.mx/dirapp/intro.aspx?version=0 (accessed July 4, 2021).

163 CASALUD / MIDO - Fundación Carlos Slim | Fundación Carlos Slim. https://fundacioncarlosslim.org/investigacion-e-innovacion/modelo-casalud-mido/ (accessed July 4, 2021).

164 Uribe-Carvajal R, Jiménez-Aguilar A, Morales-Ruan M del C, *et al.* Percepción del peso corporal y de la probabilidad de desarrollar obesidad en adultos mexicanos. *Salud Publica Mex* 2018; **60**: 254–62.

165 UNIVERSIDAD AUTÓNOMA DEL ESTADO DE MÉXICO FACULTAD DE ENFERMERÍA Y OBSTETRICIA. .

166 Ven 'normal' la obesidad, advierten - Alianza por la Salud Alimentaria. https://alianzasalud.org.mx/2014/08/ven-normal-la-obesidad-advierten/ (accessed Aug 14, 2021).

167 Dommarco JÁR. Obesidad en México: recomendaciones para una política de Estado. Ciudad de México: UNAM, 2013 https://www.anmm.org.mx/publicaciones/Obesidad/obesidad.pdf (accessed Aug 14, 2021).

168 A B. Biocultural aspects of obesity in young Mexican schoolchildren. *Am J Hum Biol* 2003; **15**: 446–60.

169 Malanda U, Welschen L, Riphagen I, Dekker J, Nijpels G, Bot S. Self-monitoring of blood glucose in patients with type 2 diabetes mellitus who are not using insulin. *Cochrane Libr* 2012. DOI:10.1002/14651858.CD005060.PUB3.

170 Villalpando MEG, Villalpando CG, Pérez BA, Stern M. Diabetic retinopathy in Mexico. Prevalence and clinical characteristics. *undefined* 1994.

171 ELVIA RODRÍGUEZ-VILLALOBOS, M.C., ECTOR JAIME RAMÍREZ-BARBA, M.C., FERNANDO CERVANTES-AGUAYO MC. Frecuencia y oportunidad del diagnóstico de retinopatía diabética. *Salud Publica Mex* 1994; **36**: 275–80.

172 Lourdes Cristina Carrillo-Alarcóna, Erika López-López, Crescencio Hernández-Aguilar JAM-C. Prevalencia de retinopatía diabética en pacientes con diabetes mellitus tipo 2 en Hidalgo, México | Revista Mexicana de Oftalmología. *Rev Mex Oftalmol* 2011; **85**. https://www.elsevier.es/es-revista-revista-mexicana-oftalmologia-321-articulo-prevalencia-retinopatia-diabetica-pacientes-con-X0187451911346320 (accessed Aug 23, 2021).

173 The Diabetic Retinopathy Barometer Report: Mexico Study Findings. 2017. https://drbarometer.com/ (accessed Feb 8, 2020).

174 Levaillant M, Lièvre G, Baert G. Ending diabetes in Mexico. *Lancet* 2019; **394**: 467–8.

175 Vos T, Lim SS, Abbafati C, *et al.* Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet* 2020; **396**: 1204–22.

176 Haffner SM, Fong D, Stern MP, *et al.* Diabetic Retinopathy in Mexican Americans and Non-Hispanic Whites. *Diabetes* 1988; **37**: 878–84.

177 Boyle JP, Honeycutt AA, Narayan KMV, *et al.* Projection of Diabetes Burden Through 2050. *Diabetes Care* 2001; **24**: 1936–40.

178 Klein R, Klein BEK, Moss SE, Davis MD, DeMets DL. The Wisconsin Epidemiologic Study of Diabetic Retinopathy: II. Prevalence and Risk of Diabetic Retinopathy When Age at Diagnosis Is Less Than 30 Years. *Arch Ophthalmol* 1984; **102**: 520–6.

179 EY C, MD D, RP D, *et al.* The effects of medical management on the progression of diabetic retinopathy in persons with type 2 diabetes: the Action to Control Cardiovascular Risk in Diabetes (ACCORD) Eye Study. *Ophthalmology* 2014; **121**: 2443–51.

180 Group TA to CCR in DF-O (ACCORDION) ESG and the A to CCR in DF-O (ACCORDION) S. Persistent Effects of Intensive Glycemic Control on Retinopathy in Type 2 Diabetes in the Action to Control Cardiovascular Risk in Diabetes (ACCORD) Follow-On Study. *Diabetes Care* 2016; **39**: 1089–100.

181 Turner R. Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). *Lancet* 1998; **352**: 837–53.

182 Stratton IM, Adler AI, Neil HAW, *et al.* Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): prospective observational study. *BMJ* 2000; **321**: 405–12.

183 Turner R, Holman R, Stratton I, *et al.* Tight blood pressure control and risk of macrovascular and microvascular complications in type 2 diabetes: UKPDS 38. *BMJ* 1998; **317**: 703–13.

184 Stols, S. & Pill S. MAKING SENSE OF SCREENING Weighing up the benefits and harms of health screening programmes. 2015 www.senseaboutscience.org (accessed Sept 25, 2021).

185 Wilson JMG, Jungner G, World Health Organization. Principles and practice of screening for disease / J. M. G. Wilson, G. Jungner. 1968; : Russian version of nos. 31-46 bound together (barc.

186 Scanlon PH. Chapter 4: Screening for diabetic retinopathy; In Practical Manual of Diabetic Retinopathy Management, Second Edi. John Wiley & Sons, Ltd, 2017 DOI:10.1002/9781119058984.CH4.

187 Fernando Barría von- E, Martínez Castro F, Juan Verdagier Terradella P. 2015 Actualización de la Guía clínica de Retinopatía Diabética para Latinoamérica DIRIGIDA A OFTALMÓLOGOS Y

PROFESIONALES DE LA SALUD GUIA ICO-PAAO-IAPB Asociación Panamericana de Oftalmología PAAO Programa Visión 2020/IAPB Latinoamérica Consejo Internacional de Oftalmología ICO. .

188 SP H, DM B, C N, MC W, J V. Sensitivity and specificity of photography and direct ophthalmoscopy in screening for sight threatening eye disease: the Liverpool Diabetic Eye Study. *BMJ* 1995; **311**: 1131.

189 SSA. Diagnóstico nacional de infraestructura y procesos de las unidades de salud. 2018. http://www.tablerocronicassic-sinba.com/TableroDiagnosticoInfraestructura/Infraestructura (accessed Aug 24, 2021).

190 PF S, J O, F S, *et al.* The value of digital imaging in diabetic retinopathy. *Health Technol Assess* 2003; **7**. DOI:10.3310/HTA7300.

191 Piyasena MMPN, Murthy GVS, Yip JLY, *et al.* Systematic review and meta-analysis of diagnostic accuracy of detection of any level of diabetic retinopathy using digital retinal imaging. *Syst Rev 2018 71* 2018; **7**: 1–18.

192 Ahmed J, Ward TP, Bursell S-E, Aiello LM, Cavallerano JD, Vigersky RA. The Sensitivity and Specificity of Nonmydriatic Digital Stereoscopic Retinal Imaging in Detecting Diabetic Retinopathy. *Diabetes Care* 2006; **29**: 2205–9.

193 Piyasena MMPN, Murthy GVS, Yip JLY, *et al.* Systematic review on barriers and enablers for access to diabetic retinopathy screening services in different income settings. *PLoS One* 2019; **14**: e0198979.

194 Patz A, Fine S, Finkelstein D, *et al.* Photocoagulation Treatment of Proliferative Diabetic Retinopathy: The Second Report of Diabetic Retinopathy Study Findings. *Ophthalmology* 1978; **85**: 82–106.

195 Photocoagulation for Diabetic Macular Edema: Early Treatment Diabetic Retinopathy Study Report Number 1 Early Treatment Diabetic Retinopathy Study Research Group. *Arch Ophthalmol* 1985; **103**: 1796–806.

196 Bailey CJ, Grant PJ. The UK Prospective Diabetes study. *Lancet* 1998; **352**: 1932.

197 Elman MJ, Aiello LP, Beck RW, *et al.* Randomized Trial Evaluating Ranibizumab Plus Prompt or Deferred Laser or Triamcinolone Plus Prompt Laser for Diabetic Macular Edema. *Ophthalmology* 2010; **117**: 1064-1077.e35.

198 JG G, AR G, LM J, *et al.* Panretinal Photocoagulation vs Intravitreous Ranibizumab for Proliferative Diabetic Retinopathy: A Randomized Clinical Trial. *JAMA* 2015; **314**: 2137–46.

199 LM A. Perspectives on diabetic retinopathy. *Am J Ophthalmol* 2003; **136**: 122–35.

200 Photocoagulation treatment of proliferative diabetic retinopathy. Clinical application of Diabetic Retinopathy Study (DRS) findings, DRS Report Number 8. The Diabetic Retinopathy Study Research Group. *Ophthalmology* 1981; **88**: 583–600.

201 JG G, AR G, D L, *et al.* Five-Year Outcomes of Panretinal Photocoagulation vs Intravitreous Ranibizumab for Proliferative Diabetic Retinopathy: A Randomized Clinical Trial. *JAMA Ophthalmol* 2018; **136**: 1138–48.

202 AJ B, H Q, AN A, *et al.* Observational study of the development of diabetic macular edema following panretinal (scatter) photocoagulation given in 1 or 4 sittings. *Arch Ophthalmol (Chicago, Ill 1960)* 2009; **127**: 132–40.

203 JG G, AR G, LM J, *et al.* Panretinal Photocoagulation vs Intravitreous Ranibizumab for Proliferative Diabetic Retinopathy: A Randomized Clinical Trial. *JAMA* 2015; **314**: 2137–46.

204 Gao S, Lin Z, Shen X. Anti-Vascular Endothelial Growth Factor Therapy as an Alternative or Adjunct to Pan-Retinal Photocoagulation in Treating Proliferative Diabetic Retinopathy: Meta-Analysis of Randomized Trials. *Front Pharmacol* 2020; **11**: 1–11.

205 Shah CP, Chen C. Review of Therapeutic Advances in Diabetic Retinopathy. *Ther Adv Endocrinol Metab* 2011; **2**: 39.

206 Pedraza CC, Matus-López M, Báscolo E. Fiscal space for Health in the Americas: Is economic growth sufficient? *Rev Panam Salud Publica/Pan Am J Public Heal* 2018; **42**. DOI:10.26633/RPSP.2018.86.

207 E V-R, AM S-M, A M-J, ME G-E, G N-R, ER C-D. The cost of diabetes mellitus and its impact on health spending in Mexico. *Arch Med Res* 2000; **31**: 511–4.

208 Riddle MC, Herman WH. The Cost of Diabetes Care—An Elephant in the Room. *Diabetes Care* 2018; **41**: 929–32.

209 The Cost of Diabetes | ADA. https://www.diabetes.org/resources/statistics/cost-diabetes (accessed Sept 18, 2021).

210 Gallardo-Rincón H, Montoya A, Saucedo-Martínez R, *et al.* Integrated Measurement for Early Detection (MIDO) as a digital strategy for timely assessment of non-communicable disease profiles and factors associated with unawareness and control: a retrospective observational study in primary healthcare facilities in Mexico. *BMJ Open* 2021; **11**: e049836.

211 Tratamiento de la DIABETES D. GUÍA DE PRÁCTICA CLÍNICA GPC. 2016. http://www.cenetec.salud.gob.mx/contenidos/gpc/catalogoMaestroGPC.html (accessed Aug 22, 2021).

212 Tablero MIDO Emabarzo Web. http://www.mido-global.com.mx/dirapp/midoEmbarazo.aspx?version=0 (accessed Aug 22, 2021).

213 Basto-Abreu A, Barrientos-Gutiérrez T, Rojas-Martínez R, *et al.* Prevalencia de diabetes y descontrol glucémico en México: resultados de la Ensanut 2016. *Salud Publica Mex* 2020; **62**: 50–9.

214 Gallardo-Rincón H, Cantoral A, Arrieta A, *et al.* Review: Type 2 diabetes in Latin America and the Caribbean: Regional and country comparison on prevalence, trends, costs and expanded prevention. *Prim Care Diabetes* 2020; published online Oct. DOI:10.1016/j.pcd.2020.10.001.

215 Comunicado No. 023 LA OFICIALÍA MAYOR DE LA SHCP DIO A CONOCER EL PROCEDIMIENTO DE LICITACIÓN PÚBLICA INTERNACIONAL PARA COMPRA | Secretaría de Hacienda y Crédito Público | Gobierno | gob.mx. https://www.gob.mx/shcp/prensa/comunicado-no-023-la-oficialia-mayor-de-la-schp-dio-a-conocer-el-procedimiento-de-licitacion-publica-internacional-para-compra-de-medicamentos-y-material-de-curacion?idiom=es (accessed Aug 22, 2021).

216 K R, E de N, H van den H, C van W. Screening for diabetic retinopathy by general practitioners. *Scand J Prim Health Care* 1992; **10**: 306–9.

217 CONEVAL. Anexo Estadístico pobreza 2016. https://www.coneval.org.mx/Medicion/MP/Paginas/AE_pobreza_2016.aspx (accessed Aug 24, 2021).

218 CONEVAL. Índice Rezago Social 2020. 2020.

https://www.coneval.org.mx/Medicion/IRS/Paginas/Indice_Rezago_Social_2020.aspx (accessed Aug 24, 2021).

219 Guillem López-Casasnovas, Berta Rivera LC. Chapter 4: On the health poverty trap. In: Health and Economic Growth: Findings and Policy Implications. Boston, US.: The MIT Press, 2005: 95–9.

220 Sosa-Rubí SG, Seiglie JA, Chivardi C, *et al.* Incremental risk of developing severe covid-19 among mexican patients with diabetes attributed to social and health care access disadvantages. *Diabetes Care* 2021; **44**: 373–80.

221 Lancet T. Editorial Turning evidence into action on diabetes. *Lancet* 2020; **396**: 1535.

222 Atkinson MA, Powers AC. Distinguishing the real from the hyperglycaemia: does COVID-19 induce diabetes? *Lancet Diabetes Endocrinol* 2021; **9**: 328–9.

223 T S, RJ T, ME C, P Z. Potential metabolic and inflammatory pathways between COVID-19 and new-onset diabetes. *Diabetes Metab* 2021; **47**. DOI:10.1016/J.DIABET.2020.10.002.

224 T S, MC A, T S. New-onset diabetes in 'long COVID'. *J Diabetes* 2021; **13**: 693–4.

225 D A. Can COVID-19 cause diabetes? *Nat Metab* 2021; **3**: 123–5.

226 Hidalgo reporta saturación en 18 hospitales por covid-19. https://www.milenio.com/ciencia-y-salud/hidalgo-reporta-saturacion-18-hospitales-covid-19 (accessed Aug 25, 2021).

227 En 24 horas se saturan 2 hospitales covid; suman 10 en Hidalgo. https://hidalgo.lasillarota.com/estados/en-24-horas-se-saturan-2-hospitales-covid-suman-10-en-hidalgo/467202 (accessed Aug 25, 2021).

228 Mantienen 9 municipios ocupación de 100% en camas generales para Covid-19 | El Economista. https://www.eleconomista.com.mx/politica/Mantienen-9-municipios-ocupacion-de-100-en-camas-generales-para-Covid-20210314-0072.html (accessed Aug 25, 2021).

229 Alerta DGE por incremento de Covid 19 en Hidalgo; piden reforzar medidas. https://hidalgo.quadratin.com.mx/principal/alerta-dge-por-incremento-de-covid-19-en-hidalgo-piden-reforzar-medidas/ (accessed Aug 25, 2021).

230 Aprende - Fundación Carlos Slim. 2021. https://aprende.org/ (accessed Aug 26, 2021).

231 Europe S for DR in. Impact of New Technologies. Manchester, UK, 2016.

232 Stefánsson E, Bek T, Porta M, Larsen N, Kristinsson JK, Agardh E. Screening and prevention of diabetic blindness. *Acta Ophthalmol Scand* 2000; **78**: 374–85.

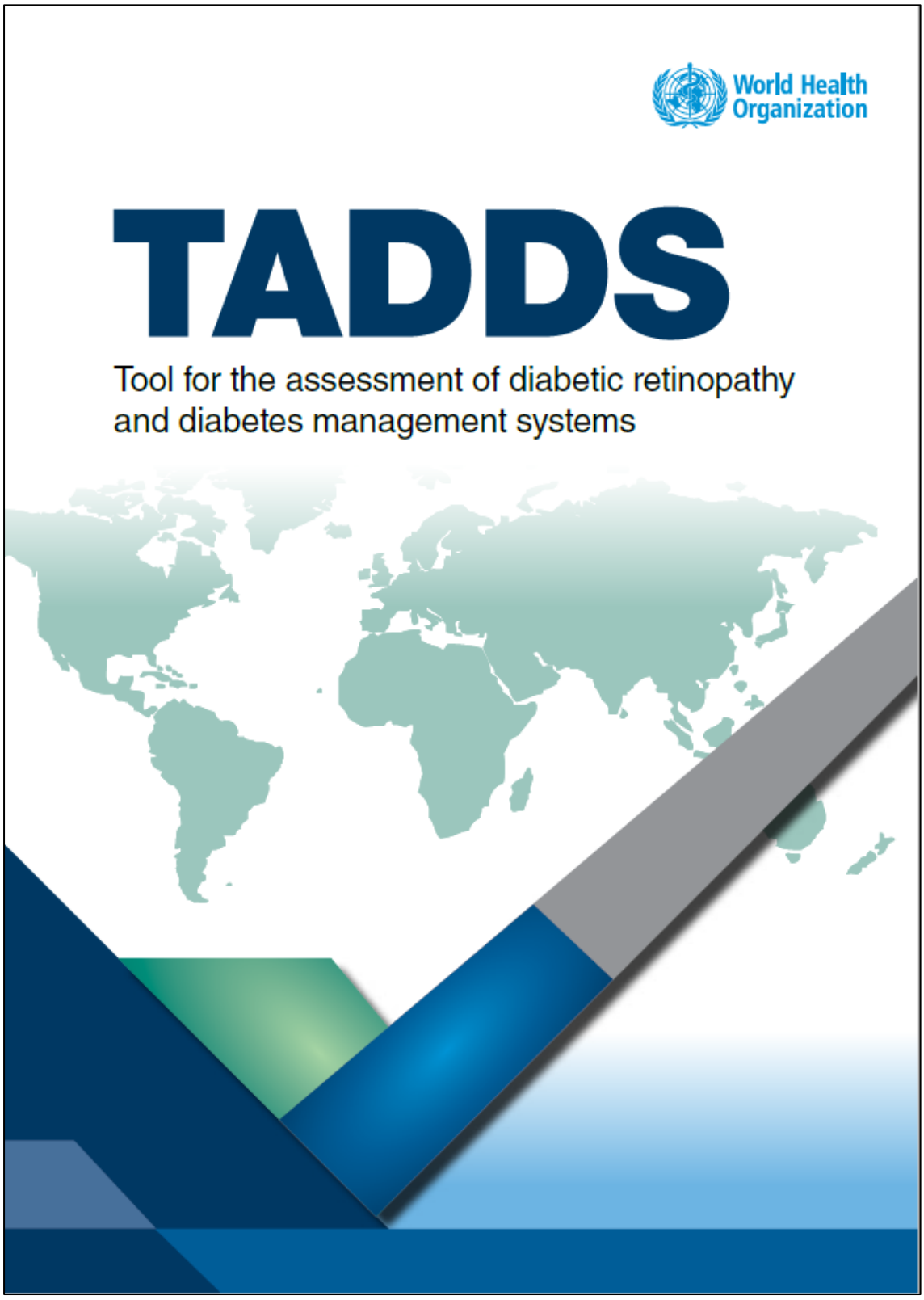
233 Amoaku WM, Ghanchi F, Bailey C, *et al.* Diabetic retinopathy and diabetic macular oedema pathways and management: UK Consensus Working Group. *Eye 2020 341* 2020; **34**: 1–51.

234 WHO/Europe. Diabetic retinopathy screening: a short guide (2020). https://www.euro.who.int/en/publications/abstracts/diabetic-retinopathy-screening-a-short-guide-2020 (accessed Aug 25, 2021).

235 Kliner M, Fell G, Gibbons C, Dhothar M, Mookhtiar M, Cassels-Brown A. Diabetic retinopathy equity profile in a multi-ethnic, deprived population in Northern England. *Eye* 2012; **26**: 671.

8. APPENDIX

Appendix A. Tool for the assessment of diabetic retinopathy and diabetes management systems (TADDS).



PRIORITIES, POLICIES AND PROGRAMMES

SECTION 1

NATIONAL DIABETES PLAN/PROGRAMME

1. Is diabetes listed as a national health priority?

   ○ Yes ○ No

2. Is diabetic retinopathy (DR) listed as a priority in the national prevention of blindness plan?

   ○ Yes ○ No

3. Does your country have a national diabetes plan?

   ○ Yes ○ No

4. If so, what does this national plan cover?

   ☐ Primary prevention of diabetes
   ☐ Complications (including vision impairment)
   ☐ Community awareness and patient education
   ☐ Clinical care, services, and supplies

   Remarks:

5. Is there a national policy on food and/or nutrition?

   ○ Yes ○ No

6. Is there a national programme on food and/or nutrition?

   ○ Yes ○ No

   Name of programme:

   Lead organization responsible for the programme:

7. Is there a national policy on diabetes prevention?

○ Yes ○ No

8. Is there a national diabetes prevention programme?

○ Yes ○ No

Name of programme:

Lead organization responsible for the programme:

9. Is there a national diabetes association?

○ Yes ○ No

a. What does it do?

- ☐ Patient education and awareness
- ☐ Clinician education and awareness
- ☐ Policy development and advocacy
- ☐ Networks between service providers and people with diabetes

b. What health promotion and patient education strategies are used by the diabetes association?

Select the number[1] below that best represents the situation in the country:
Existence of priority, policies and programmes for DM: ○ 1 ○ 2 ○ 3 ○ 4

[1] Key:

1 – DM is not a priority; there is no national plan and no national programme.

2 – DM is listed as a priority; there is a national plan but no programme has been implemented.

3 – DM is listed as a priority; a national plan has been formulated and a programme is in place but does not cover the whole country.

4 – DM is listed as a priority; both a plan and a programme are in place and there is national coverage.

CLINICAL MANAGEMENT GUIDELINES

10. Are there guidelines for the management of diabetes?

○ Yes ○ No

(If yes, please give the full title of the clinical management guidelines most commonly used and provide a copy.)

a. Is diabetic retinopathy included as a component of these guidelines?

○ Yes ○ No

b. For what levels of the health care system (primary, secondary, tertiary) are the guidelines applicable?

c. What is the intended target audience (e.g. primary care workers, specialists) for the guidelines?

11. Are evidence-based guidelines available for the management of diabetic retinopathy?

○ Yes ○ No

(If yes, please give the full title of the clinical management guidelines most commonly used and provide a copy.)

a. Do they cover:

☐ prevention of vision loss from diabetic retinopathy?
☐ treatment?
☐ follow-up?

b. For what levels of the health care system are the guidelines applicable?

☐ Primary
☐ Secondary
☐ Tertiary

c. The guidelines are:

○ Evidence-based ○ Consensus-based ○ Mixture of both

If consensus-based, who (stakeholders) was involved in guideline development?

12. Are the guidelines being used?

Subjective rating scale: 1 = unused, 12 = widely used (click the appropriate number)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12

13. Describe how the intended audience is made aware of the existence of the guidelines? How were they disseminated (e.g. in print, by website)? In what languages are they produced?

Select the number[1] below that best represents the situation in the country:				
Guidelines for clinical management of DM:	☐ **1**	☐ **2**	☐ **3**	☐ **4**
Guidelines for clinical management of DR:	☐ **1**	☐ **2**	☐ **3**	☐ **4**

[1] Key:

1 – There are no ministry of health-recommended guidelines.

2 – Ministry of health guidelines have been formulated but health professionals are unaware of their availability and thus they are not widely used.

3 – Ministry of health guidelines are available and known to the appropriate audience but they are not widely followed.

4 – Ministry of health guidelines have been formulated and are commonly followed.

Additional information for Section 1

SERVICE DELIVERY

SECTION 2

NETWORKS AND LINKAGES

14. Describe how people with newly diagnosed diabetes are identified.

    a. Where are the services located (village, district, regional, provincial, tertiary levels of care)?

    b. The facilities are:

    ○ Private ○ Public

15. Describe how ongoing care of people with diabetes is performed.

    a. Where are the facilities located (village, district, regional, provincial, tertiary levels of care)?

    b. The facilities are:

    ○ Private ○ Public

16. Describe the access to care services for people with diabetes.

    a. What proportion of the population can access this service?

    b. What are the barriers that prevent access to services?

17. What services are available at the community level for people with diabetes?

    a. Clinical services:

    ☐ for patient identification and risk assessment

    b. Patient education and support services:

    ☐ for diabetes

    ☐ for diabetic retinopathy

18. Is there a specialist diabetes centre?

○ Yes ○ No

a. If yes, what services does it provide?

b. What proportion of the population has access to these services?

Select the number[1] below that best represents the situation in the country:
Location of DM services and accessibility to population in need: ☐ 1 ☐ 2 ☐ 3 ☐ 4

[1] Key:

1 – Services available in few places and to few people.

- Services are not available everywhere; they can be found only in large hospitals and are accessible only to those who can pay.

2 – Some services are available to part of the population.

- Services are available in regional hospitals or health centres and are partly paid by the patients. Populations in rural areas cannot reach services easily; transport to the health facilities and the cost of service are the main barriers.

3 – Services are available everywhere but do not reach some of the population.

- Services are available in most rural and urban areas providing care at district, regional, provincial and tertiary levels; however, costs and transport are barriers for some patients.

4 – Services are available everywhere for the whole population.

- Services are available in all locations and costs are paid by insurance schemes, are subsidized by the state, or are available free of charge.

DIABETIC RETINOPATHY SCREENING

19. Are people with diabetes routinely referred for eye examinations?

○ Yes ○ No

a. Does this include referral of people who are asymptomatic?

○ Yes ○ No

b. Are people referred only if they report symptoms of vision loss?

○ Yes ○ No

c. Is an eye examination incorporated into the annual cycle of care for people with diabetes?

○ Yes ○ No

20. Is there a community screening programme for diabetic retinopathy?

○ Yes ○ No

a. How are people with diabetes recruited for screening?

b. What personnel are involved?

c. Is any outreach screening provided?

○ Yes ○ No

d. Coverage of screening?

e. Who pays for the screening?

21. Where are eye examinations for diabetic retinopathy performed most commonly in villages, at district, regional, provincial, tertiary levels of care)?

a. What proportion of the population can access this service (no one, 30%, 60%, 90%, 100%)?

b. What are the barriers that prevent access to services?

c. The services are:

○ Private ○ Public

Select the number[1] below that best represents the situation in the country:
Location of DM services and accessibility to population in need: ☐ 1 ☐ 2 ☐ 3 ☐ 4

[1] Key:

1 – Services available in few places and to few people.

- Services are not available everywhere; they can be found only in large hospitals and are accessible only to those who can pay.

2 – Some services are available to part of the population.

- Services are available in regional hospitals or health centres and are partly paid by the patients. Populations in rural areas cannot reach services easily; transport to the health facilities and the cost of service are the main barriers.

3 – Services are available everywhere but do not reach some of the population.

- Services are available in most rural and urban areas providing care at district, regional, provincial and tertiary levels; however, costs and transport are barriers for some patients.

4 – Services are available everywhere for the whole population.

- Services are available in all locations and costs are paid by insurance schemes, are subsidized by the state, or are available free of charge.

22. Describe the networks between services for diabetes care and eye care.

a. Stakeholders

b. Referral pathways (one-way, reciprocal)

c. What information is shared between practitioners?

23. Are any nongovernmental organizations (NGOs) involved in the care of people with diabetes and diabetic retinopathy?

○ Yes ○ No

If so, what roles do they perform in diabetes and in eye examination for people with diabetes (health promotion, screening, laser, vitreoretinal surgery)?

Select the number[1] below that best represents the situation in the country:
Networks between the care providers for DM and DR: ☐ 1 ☐ 2 ☐ 3 ☐ 4

[1] Key:

1 – There is no known collaboration between separate providers of care for DM and DR.

2 – Few centres provide patient-centred care.

3 – Some centres provide patient-centred care by means of collaboration between DM and DR services.

4 – Most centres provide patient-centred care based on collaboration between DM and DR services.

Additional information for Section 2

HEALTH WORKFORCE

SECTION 3

24. What categories of health professionals (endocrinologist; ophthalmologist; primary care physician; general, diabetes or ophthalmic-trained nurse; dietician; etc.) are available to care for people with diabetes?

What is the ratio of providers to patients at each level of the health system?

25. What aspects of diabetes management are included in the teaching curriculum for primary health care workers (nurses and primary care physicians)?

- ☐ Awareness of complications of diabetes – specifically, vision loss from diabetic retinopathy
- ☐ Health education for patients
- ☐ Need for and timing of referral for eye examination
- ☐ Management of diabetic retinopathy

26. How is continuing medical education provided to primary health care workers?

- ☐ Formal training by government, university, professional organizations
- ☐ Regular informal updates
- ☐ Workshops
- ☐ Updates on guidelines

Select the number[1] below that best represents the situation in the country:
Training opportunities and quality for DM and DR care providers: ☐ 1 ☐ 2 ☐ 3 ☐ 4

[1] Key:

1 – Largely inadequate.

2 – Few training opportunities; consequently fewer human resources than needed.

3 – Training available only in large cities and hospitals.

4 – Training for DM and DR is appropriate and of good quality.

HEALTH TECHNOLOGY

SECTION 4

27. Are the following investigations/equipment available?

- ☐ Biochemical laboratory tests for HbA1c (glycated haemoglobin), lipids, creatinine, urinary protein
- ☐ Blood glucose meter (owned/kept by patients with diabetes or by the health service)
- ☐ Slit lamp
- ☐ Direct ophthalmoscope

28. What technologies are used to perform retinal examination for diabetic retinopathy?

- ☐ Dilated eye examination by ophthalmologist
- ☐ Dilated eye examination by refractionist/optometrist
- ☐ Retinal imaging – mydriatic camera
- ☐ Retinal imaging – non-mydriatic camera

29. Where are these technologies available (villages, district, regional, provincial, tertiary levels of care)?

Select the number[1] below that best represents the situation in the country:

Accessibility of health technology: ☐ 1 ☐ 2 ☐ 3 ☐ 4

[1] Key:

1 – Modern examination technology not available to the majority of patients.

2 – Modern examination technology available only in major hospitals and private clinics.

3 – Modern examination technology available in most provincial hospitals and clinics.

4 – Modern examination technology available to all patients.

Additional information for Sections 3 and 4

HEALTH INFORMATION MANAGEMENT SYSTEMS

SECTION 5

30. What nationally agreed health population indicators of diabetes are monitored?

- ☐ Prevalence
- ☐ Incidence
- ☐ Not measured

How often are they measured?

31. What nationally agreed health population indicators of diabetic retinopathy are monitored?

- ☐ Prevalence of vision impairment and blindness
- ☐ Not measured

How often are they measured?

32. Describe the methods used (surveys, hospital data, health insurance statistics) to collect this information.

33. Describe how the information is collated and reported (standardized data set).

34. What information about individual patients with diabetes is recorded in their patient medical records in hospitals?

- ☐ Risk factors
- ☐ Complications – including diabetic retinopathy
- ☐ Previous eye examination for diabetic retinopathy
- ☐ Treatments
- ☐ Follow-up

35. Is there a recall system for people with diabetes to have follow-up eye examination?

◯ Yes ◯ No

☐ Communication methods: personal record books, information cards

☐ mHealth: text messaging reminders using mobile phones

Select the number[1] below that best represents the situation in the country:
Knowledge of disease burden: ☐ 1 ☐ 2 ☐ 3 ☐ 4

[1] Key:

1 – Prevalence of DM and DR is neither known nor estimated; information about patients is inadequate.

2 – Prevalence of DM is known but not the prevalence of DR.

or

Prevalence of DR is known but not the prevalence of DM, and patients' records are not utilized.

3 – Prevalence of both DM and DR is known or has been estimated; patients' records are used to analyse data at national level.

4 – Prevalence of both DM and DR is known or has been estimated; patients' records are collated, analysed and regularly published.

Additional information for Section 5

HEALTH PROMOTION FOR DIABETES AND DIABETIC RETINOPATHY

SECTION 6

36. Is information provided to the community about diabetes?

- ☐ Symptoms and signs
- ☐ Risk factors
- ☐ Complications
- ☐ Management
- ☐ Where to seek help

37. Is information provided to the community about diabetic retinopathy?

- ○ Yes
- ○ No

38. How is community education regarding diabetes delivered?

- ☐ Print media
- ☐ mHealth: text messaging reminders using mobile phones
- ☐ Radio/television

39. What is the coverage of health promotion and patient education?

- ☐ National
- ☐ Provincial
- ☐ District

40. Are people with diabetes made aware of diabetic patients' organizations?

- ○ Yes
- ○ No

How are patients' support organizations made accessible to disadvantaged groups of the population:

In rural locations?

In what languages/dialects?

For people with disabilities?

41. Give examples of how initiatives such as World Diabetes Day and World Sight Day are used to educate people and medical professionals on vision impairment from diabetes.

Select the number[1] below that best represents the situation in the country:
Information and education provided to the community and to patients on DM and DR: ☐1 ☐2 ☐3 ☐4

[1] Key:

1 – Little information is provided to the community and little education to patients .

2 – Information to the community is provided occasionally and only through national-level media; not all patients receive education.

3 – Information is provided at national and provincial level; most patients receive education.

4 – Information is provided to the community at all levels; all patients receive education and patients' organizations are actively involved.

Additional information for Section 6

HEALTH FINANCING

SECTION 7

42. How are interventions for people with diabetes financed?

Activity	% of cost funded by government	% of cost funded by private insurance	% of cost funded by patient (out-of-pocket)	% of cost funded by NGO	% of cost funded by others (please specify)
Medical treatment					
Hospital treatment					
Medications					
Laboratory tests					
Other:					

43. How are interventions for people with diabetic retinopathy financed?

Activity	% of cost funded by government	% of cost funded by private insurance	% of cost funded by patient (out-of-pocket)	% of cost funded by NGO	% of cost funded by others (please specify)
Prevention (retinal screening)					
Laser photocoagulation					
Vitreoretinal surgery					
Other:					

Additional information for Section 7

Appendix B. Example of the TADDS instrument programmed in RedCap (Variables in Spanish).

Confidential

Identificacion

Record ID	_____
ID estudio	_____
Fecha	_____
Nombre	_____
Puesto	_____
email	_____
perfil general	◯ politica publica ◯ implementador operativo ◯ implementador clinico ◯ sociedad civil
perfil especifico	◯ politica publica nacional ◯ politica publica estatal ◯ politica publica local ◯ implementador operativo nacional ◯ implementador operativo estatal ◯ implementador operativo local ◯ implementador clinico local ◯ AC nacional ◯ AC estatal ◯ AC local
ubicacion	◯ Nacional ◯ Hidalgo ◯ Pachuca ◯ Tulancingo

1) Prioridades, politicas y programas

1.1) ¿Es la diabetes una prioridad sanitaria nacional?
- ◯ Si
- ◯ No
- ◯ No lo se

1.2) ¿Esta incluida la retinopatia diabetica entre las prioridades del plan nacional para la prevencion de la ceguera?
- ◯ Si
- ◯ No
- ◯ No lo se

1.3) ¿Dispone su país de un plan nacional contra la diabetes?
- ◯ Si
- ◯ No
- ◯ No lo se

1.4) En caso afirmativo, ¿qué servicios cubre ese plan?
- ☐ Prevención primaria de la diabetes
- ☐ Complicaciones (incluida la discapacidad visual)
- ☐ Concienciación de la población y educación de los pacientes
- ☐ Atención clínica, servicios y suministros

1.4.1 Observaciones:

1.5) ¿Hay una normativa nacional de alimentación o nutrición?
- ◯ Si
- ◯ No
- ◯ No lo se

1.6) ¿Hay un programa nacional de alimentación o nutrición?
- ◯ Si
- ◯ No
- ◯ No lo se

1.6.1) Nombre del programa

_____

1.6.2) Principal organismo responsable

_____

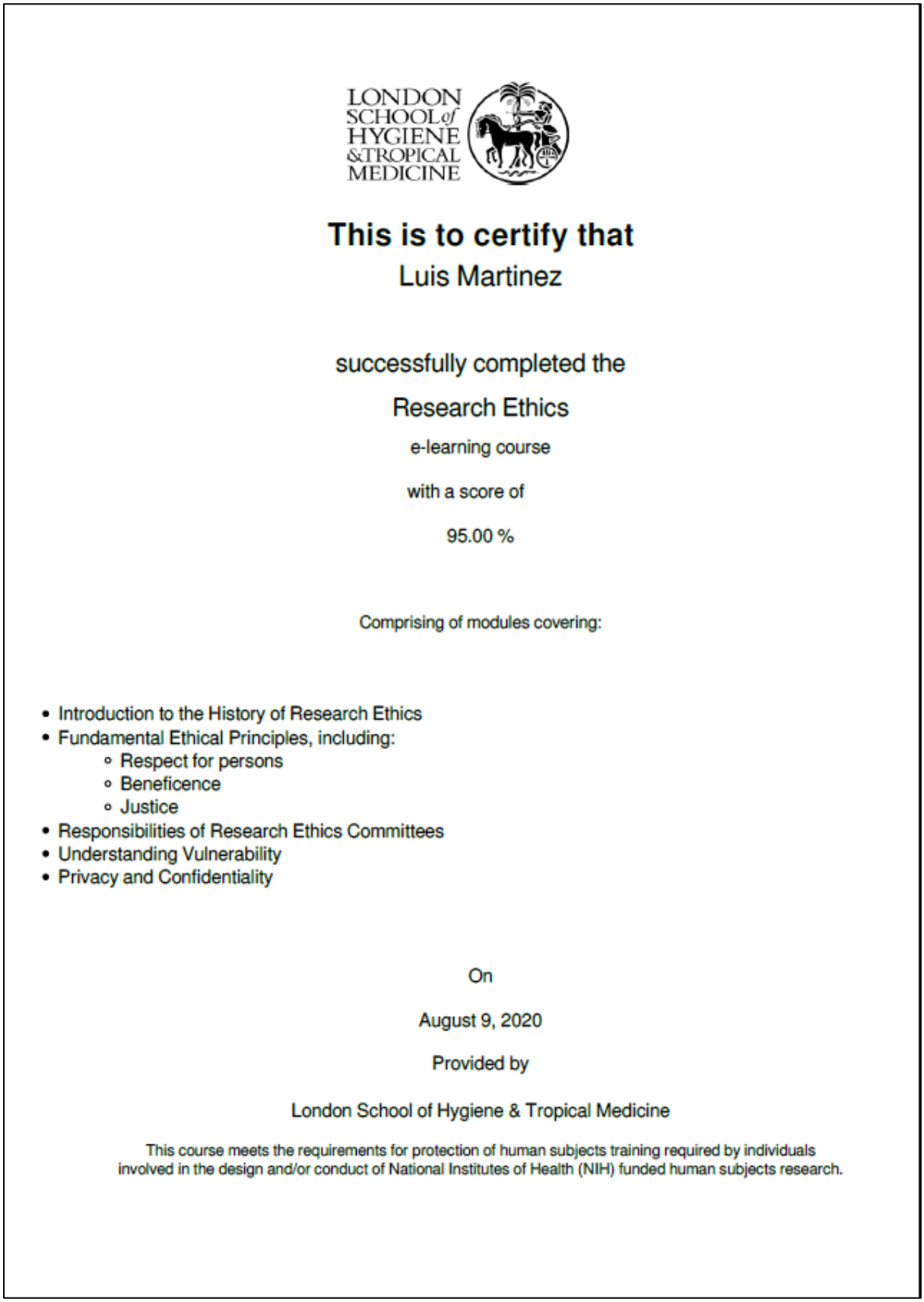
1.7) ¿Hay una normativa nacional de prevención de la diabetes?
- ◯ Si
- ◯ No
- ◯ No lo se

1.8) ¿Hay un programa nacional para la prevención de la diabetes?
- ◯ Si
- ◯ No
- ◯ No lo se

1.8.1) Nombre del programa

_____

Appendix C. Certificate of the online Research Ethics from LSHTM.



LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

This is to certify that

Luis Martinez

successfully completed the

Research Ethics

e-learning course

with a score of

95.00 %

Comprising of modules covering:

- Introduction to the History of Research Ethics
- Fundamental Ethical Principles, including:
  - Respect for persons
  - Beneficence
  - Justice
- Responsibilities of Research Ethics Committees
- Understanding Vulnerability
- Privacy and Confidentiality

On

August 9, 2020

Provided by

London School of Hygiene & Tropical Medicine

This course meets the requirements for protection of human subjects training required by individuals involved in the design and/or conduct of National Institutes of Health (NIH) funded human subjects research.

Appendix D. Approval of the research protocol by research committee of the Health Services of the State of Hidalgo.

Secretaría de Salud
Hidalgo crece contigo

El éxito es el resultado del trabajo duro y la persistencia.
¡Felicidades a las y los trabajadores sociales!

M. en C. Imelda Menchaca Armenta
Presidenta
ASUNTO: Dictamen

Pachuca, Hidalgo a 19 de agosto de 2020

Dr. Luis Alberto Martínez Juárez
INVESTIGADOR PRINCIPAL
PRESENTE

Comunico a usted que una vez realizada la segunda valoración del protocolo con folio FSSA2020092, titulado: "Evaluación de los servicios públicos de salud la atención de la Diabetes Mellitus y la Retinopatía Diabética en el estado de Hidalgo, México", el Comité de Investigación en Salud de los SSH, emite el siguiente dictamen:

APROBADO

De acuerdo con lo establecido en los Procedimientos Normalizados de Operación correspondiente al ingreso de protocolo. No omito informar a usted que cualquier cambio al citado protocolo deberá solicitar autorización mediante enmienda; así mismo, deberá presentar informe a este Comité de los avances del proyecto según cronograma.

Este dictamen tiene una vigencia no mayor a treinta días de acuerdo a la fecha de inicio del cronograma presentado. Transcurrido el plazo deberá iniciar el proceso de evaluación nuevamente.

Sin más por el momento, reciba usted un cordial saludo.

ATENTAMENTE

[redacted]

Appendix E. Approval of the research protocol by the research ethics committees of the London School of Hygiene and Tropical Medicine.

London School of Hygiene & Tropical Medicine
Keppel Street, London WC1E 7HT
United Kingdom
Switchboard: +44 (0)20 7636 8636

www.lshtm.ac.uk

LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

Observational / Interventions Research Ethics Committee

Dr Luis Martinez

LSHTM

22 October 2020

Dear Luis

Study Title: Assessment of public health services for diabetic retinopathy in the State of Hidalgo, Mexico.

LSHTM Ethics Ref: 22481

Thank you for responding to the Observational Committee's request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Chair.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Conditions of the favourable opinion

Approval is dependent on local ethical approval having been received, where relevant. Note: please make minor corrections to the information sheet. Section 5: typo - order, not our. Section 10: destroy not delete hard files

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document Type	File Name	Date	Version
Investigator CV	CV Luis Martinez English	04/07/2020	1
Protocol / Proposal	TADDS_ENG	08/08/2020	1
Protocol / Proposal	DrPH Review document_Luis Martinez _LSH1605009	08/08/2020	1
Information Sheet	Information sheet and consent form	08/08/2020	1
Advertisements	Recruitment letter thesis (English)	08/08/2020	1
Protocol / Proposal	INDIVIDUAL INTERVIEW TOPIC GUIDE 08082020	08/08/2020	1
Other	Research_Ethics_online_training_certificate	09/08/2020	1
Protocol / Proposal	Ethical Approval Form 2017 Thesis LM signed AF	11/08/2020	1
Local Approval	FSSA2020092. Dictamen Aprobado	17/08/2020	1
Information Sheet	Information sheet and consent form Oct 13 2020 (With corrections)	13/10/2020	2
Protocol / Proposal	Ethical Approval Form 2017 Thesis v2 signed	13/10/2020	2
Covering Letter	Covering letter from Luis Martinez to ethics response Oct 13, 2020	13/10/2020	1

After ethical review

The Chief Investigator (CI) or delegate is responsible for informing the ethics committee of any subsequent changes to the application. These must be submitted to the Committee for review using an Amendment form. Amendments must not be initiated before receipt of written favourable opinion from the committee.

The CI or delegate is also required to notify the ethics committee of any protocol violations and/or Suspected Unexpected Serious Adverse Reactions (SUSARs) which occur during the project by submitting a Serious Adverse Event form.

An annual report should be submitted to the committee using an Annual Report form on the anniversary of the approval of the study during the lifetime of the study.

At the end of the study, the CI or delegate must notify the committee using an End of Study form.

All aforementioned forms are available on the ethics online applications website and can only be submitted to the committee via the website at: http://leo.lshtm.ac.uk

Additional information is available at: www.lshtm.ac.uk/ethics

Yours sincerely,

[redacted]

Professor Jimmy Whitworth
Chair

ethics@lshtm.ac.uk
http://www.lshtm.ac.uk/ethics/

Improving health worldwide

Appendix F. Information Sheet and Consent Inform used for the study (Spanish).

LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

Hoja informativa

Título del proyecto: Evaluación de los servicios públicos de salud la atención de la Diabetes Mellitus y la Retinopatía Diabética en el Estado de Hidalgo, México.

Datos de Contacto del Investigador Responsable:
Dr. Luis Alberto Martínez Juárez
Dirección: Calle Herschel 109, Col. Anzures, C.P. 11590, Ciudad de México
Teléfono: (+52) 55 4023 1839
Correo electrónico: luis.martinez@lshtm.ac.uk

Contacto en Comités de Ética e Investigación de los Servicios de Salud del Estado de Hidalgo:

Dra. Lourdes Cristina Carrillo Alarcón, Presidente del Comité de Ética.
M. en C. Imelda Menchaca Armenta, Presidente del Comité de Investigación.

Dirección: Mariano Arista #107 Col La Surtidora, CP 42050, Pachuca de Soto, Hidalgo.
Teléfono: 01 (771) 7180770. Correo electrónico: comiteeticassh@hotmail.com

Información para los participantes:

Gracias por considerar participar en este proyecto.

Esta hoja de información describe el propósito del estudio y proporciona una descripción de su participación y sus derechos como participante, si acepta participar.

1. ¿De qué se trata este Proyecto?

Se trata de un proyecto de investigación académico como parte del programa de Doctorado profesional de Salud Pública en la Universidad *London School of Hygiene and Tropical Medicine*.

El objetivo de este estudio es realizar un análisis del sistema de salud pública para los servicios de diabetes mellitus y retinopatía diabética a nivel nacional y en Estado de Hidalgo, y proporcionar recomendaciones para fortalecer el sistema de salud.

Los objetivos específicos considerados para este proyecto son:

1. Estimar a partir de la literatura, la magnitud futura de la diabetes mellitus y la retinopatía diabética en México e Hidalgo.
2. Evaluar el sistema de salud pública para la atención de la diabetes mellitus y la retinopatía diabética desde una perspectiva Nacional y en el Estado de Hidalgo utilizando la "Herramienta para la evaluación de la retinopatía diabética y los sistemas de control de la diabetes" (TADDS) de la Organización Mundial de la Salud.
3. Identificar, desde la perspectiva Nacional y en el Estado de Hidalgo, las limitaciones de los proveedores de salud en la prestación de servicios a personas que viven con diabetes mellitus y retinopatía diabética como resultado de la pandemia por COVID-19, y posibles soluciones.
4. Identificar las principales limitaciones para mejorar los servicios para la diabetes mellitus y retinopatía diabética en el marco nacional y en el Estado de Hidalgo.
5. Proporcionar recomendaciones a tomadores de decisiones para mejorar los servicios de enfocados a la atención de diabetes mellitus y retinopatía diabética.

Esta investigación utilizará métodos de recopilación de datos cuantitativos y cuantitativos para obtener toda la información necesaria para el análisis completo del programa. Estos métodos incluyen:

- Revisión de literatura
- Entrevistas con encargados de la formulación de políticas públicas en salud e implementadores de los programas de Diabetes Mellitus y Retinopatía Diabética a nivel nacional y en el Estado de Hidalgo.

2. ¿Debo participar en este Proyecto?

Depende de usted decidir si participa o no. No tiene que participar si no lo desea. Si decide participar, se le pedirá firmar un formulario de consentimiento que puede firmar y devolver antes de la entrevista o firmar en la reunión.

3. ¿Cómo puedo participar en este proyecto?

Con el objetivo de poder evaluar completamente las diferentes áreas del sistema de salud enfocada en la prevención, manejo y control de la Diabetes Mellitus y la Retinopatía Diabética, creemos que su participación puede brindarnos información muy importante para comprender mejor esta parte del sistema de salud.

Si acepta participar, nos gustaría invitarlo a realizar una entrevista con cuestionarios diseñados por la Organización Mundial de la Salud con el objetivo de evaluar siete elementos diferentes del sistema de salud. Nos gustaría enfatizar que su participación es voluntaria y anónima. También debe saber que esta información se utilizará solo con fines académicos y de investigación.

4. ¿Es posible abandonar este estudio?

Usted puede retirarse en cualquier momento del estudio sin tener que dar una razón. Si alguna pregunta durante la entrevista le hace sentir incómodo, no tienes que responderla y puedes retirarte de la entrevista en cualquier momento por cualquier motivo. Retirarse del estudio no tendrá ningún efecto en usted. Si se retira del estudio, no conservaremos la información que ha proporcionado hasta ahora, a menos que usted autorice utilizar la información que ha proporcionado hasta el momento en que usted decide dejar de participar.

5. ¿Para qué se utilizará mi información?

Utilizaremos la información recopilada para fines académicos y de investigación como parte del proyecto del programa de doctorado en salud pública en la Universidad *London School of Hygiene and Tropical Medicine*. Las conclusiones de este proyecto ofrecerán al Ministro de Salud de Hidalgo un análisis crítico y recomendaciones para su consideración en futuras políticas y estrategias de implementación.

Con base en los resultados de este análisis, parte de este estudio podría utilizarse en una publicación científica, sin embargo, la información proporcionada por cualquier participante permanecerá anónima en todo momento, eliminando cualquier indicio que pueda conducir a la identificación de un participante.

6. ¿Mi participación y mis datos se mantendrán confidenciales?

La información que comparta en este estudio se mantendrá confidencia. Solo yo y mi supervisor tendremos acceso a los archivos y a las cintas de audio generadas de cada entrevista. Sus datos serán anonimizados; su nombre no se utilizará en ningún informe o publicación resultante del estudio. Todos los archivos digitales, transcripciones y resúmenes recibirán códigos y se almacenarán por separado

de cualquier nombre u otra identificación directa de los participantes. Cualquier copia impresa de la información de la investigación se mantendrá en archivos protegidos en todo momento.

7. ¿Qué pasa si tengo una pregunta o queja?

Si tiene alguna pregunta sobre este estudio, comuníquese con el investigador, Dr. Luis Alberto Martínez Juárez, en luis.martinez@lshtm.ac.uk.

Si tiene alguna inquietud o queja con respecto a la realización de esta investigación, comuníquese con la Universidad London School of Hygiene and Tropical Medicine a través del correo: ethics@lshtm.ac.uk

De igual forma puede ponerse en contacto con el Comité de Ética e Investigación del Estado de Hidalgo utilizando los datos proporcionados al inicio de este documento.

LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

Consentimiento informado

Título del proyecto: Evaluación de los servicios públicos de salud la atención de la Diabetes Mellitus y la Retinopatía Diabética en el Estado de Hidalgo, México.

Investigador: Dr. Luis Alberto Martinez Juarez

Mi participación en este estudio es voluntaria bajo un compromiso de gratuidad.

Acepto participar en el estudio bajo un compromiso de gratuidad	SI / NO
Entiendo que soy libre de negarme a participar en este estudio de investigación, o puedo retirar mi participación en cualquier momento sin que esto genere algún problema. Mi decisión de participar o no en este estudio de investigación no tendrá ningún impacto negativo en mí, ni personal ni profesionalmente.	SI / NO
Confirmo que he leído y entendido la hoja de información proporcionada para el estudio anterior. He tenido la oportunidad de considerar la información y hacer cualquier pregunta que tenga.	SI / NO
Entiendo que mis datos serán anónimos y mantenidos en una computadora portátil protegida con contraseña para futuras investigaciones o publicaciones.	SI / NO
Acepto que la entrevista sea grabada.	SI / NO
Acepto que mis opiniones sean citadas de forma anónima en el escrito académico de este trabajo de investigación.	SI / NO

Conserve una copia de este formulario de consentimiento.

Nombre del participante:

Firma: _____ Fecha: _____

Nombre de primer testigo:

Firma: _____ Fecha: _____

Nombre de segundo testigo:

Firma: _____ Fecha: _____

Nombre del investigador: Dr. Luis Alberto Martinez Juarez

Firma:_____ Fecha: _____

Para más información por favor contacte al investigador de este proyecto al correo:
luis.martinez@lshtm.ac.uk