



The role of primary healthcare in the
management of work-related DED in the
Netherlands

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II. Summary

Dry eye disease (DED), and especially work-related dry eye, has an increasing incidence, and is expected to become a significant public health problem, with the increasing age until retirement, and the effect of the modern, digital, working environment causing higher visual demands. The indoor environment and more demanding, eye-related tasks, are risks factors for the development of dry eye symptoms, leading to DED at these workplaces. The current management for diagnosed DED is strongly pharmaceutical-based, and research looking at solutions towards better functioning and well-being of DED patients is rare. There is also a lack of evidence about the role of healthcare professionals in DED management.

This PhD looks at: the prevalence of DED in office workers; the environmental factors involved; the negative aspects on quality of life experience; the attitude of healthcare professionals to DED management; the care given by the primary healthcare professionals; and the needs for a healthcare pathway for DED.

The PhD found that:

A substantial proportion of office workers surveyed experienced mild/moderate dry eye symptoms, and that while these were experienced more at work than at home, they had a negative impact on daily activities at work and after work, interfering with their social life.

There is a lack of in-depth knowledge in dry eye diagnosis and management in all primary healthcare professionals surveyed and education is needed in management of work-related dry eye; there is a need for a specialised DED optometrist, with a recognised qualification; inter-professional cooperation should be promoted through better communication pathways; OHPs and optometrists should work together at the association level to develop clinical care guidelines; and a chronic care pathway in DED should be developed as part of the Dutch Government healthcare reforms.

III. Table of Contents

I. Declaration	2
II. Summary	4
III. Table of Contents	6
IV. List of Figures	10
V. List of Tables	11
VI. Abbreviations	12
VII. Acknowledgements	15
1 INTRODUCTION	20
2 LITERATURE REVIEW	25
2.1 The Tear Film	25
2.2 Definition of Dry Eye Disease (DED)	26
2.2.1 Impact of blinking	28
2.2.2 Environmental factors	30
2.2.3 Indoor environment standards	31
2.3 Work-related DED	32
2.3.1 Vision-related impact of DED	34
2.3.2 Contrast sensitivity, glare and glare disability	35
2.3.3 Higher order aberrations	36
2.4 Dry eye and Quality of Life	36
2.4.1 Impact of pain and dry eye	38
2.4.2 Work productivity	38
2.5 Diagnostic tests for dry eye investigation	39
2.5.1 Dry eye questionnaires	39
2.5.2 Schirmer Test	40
2.5.3 Phenol Red Thread Test (PRT)	40
2.5.4 Tear Break-Up Time (BUT)	40
2.5.5 Osmolarity Measurement	41
2.5.6 Ocular Surface Staining	42
2.5.7 Non-Invasive Break-Up Time (NIBUT)	43
2.5.8 Lid-Parallel Conjunctival Folds (LIPCOF)	45
2.5.9 Meibography	45
2.6 Combining Diagnostic Tests	46
2.7 Prevalence publications after DEWS 2007	47

2.7.1	Prevalence using the Schaumberg three question questionnaire	48
2.7.2	Prevalence vs incidence of dry eye with Scheim symptoms-based questionnaire	50
2.8	Diagnosis and treatment	50
2.8.1	DEWS diagnostic grid and recommended management	51
2.9	Prevalence of DED in the Netherlands	52
2.10	Healthcare in the Netherlands	54
2.10.1	General Practitioner	55
2.10.2	Optometrists	55
2.10.3	Occupational Healthcare Physician (OHP)	57
2.11	Substitutional potential of the optometrist in primary healthcare	58
2.11.1	Investigation of the attitude in healthcare towards dry eye disease	58
2.12	Healthcare pathways	59
2.13	Integrated People-Centred Health Services	61
2.14	Chronic Care Model	62
2.14.1	Self-management	63
2.15	Inter-professional cooperation	63
2.16	DED pathway in the Netherlands	65
2.17	The Chronic Care model for improving outcomes	65
2.18	The International Classification of Functioning, Disability and Health	66
2.18.1	Health condition	66
2.19	Summary	68
2.19.1	DED is a very common illness	68
2.19.2	Patient must be central	69
2.19.3	Healthcare pathways	69
2.20	This PhD has two principal aims:	69
3	IMPACT OF DRY EYE SYMPTOMS AND DAILY ACTIVITIES IN A MODERN OFFICE	72
3.1	Study 1: Introduction	72
3.2	Aim	73
3.3	Methods	74
3.3.1	Recruiting participants	75
3.3.2	Location specifics	76
3.3.3	Statistical methods and analysis variables	76
3.4	Results	77
3.4.1	Prevalence, severity and management of dry eye	77
3.4.2	Working environment	79
3.4.3	Ocular symptoms at work and inhibition of work	81
3.4.4	Symptom differences per location	85
3.4.5	Inhibition at work per location	85
3.4.6	Perception of work environment per location	87

3.5	Discussion	88
3.5.1	Reported diagnosed dry eye	88
3.5.2	Use of reading materials	89
3.5.3	Symptoms	90
3.5.4	Limitations	91
3.6	Conclusions	92
3.7	Next step	92
4	EYE DISCOMFORT SYMPTOMS OF OFFICE WORKERS; SOCIAL IMPACT AND PERCEPTION OF ENVIRONMENT	94
4.1	Study 2: Introduction	94
4.2	Aim	97
4.3	Methods	97
4.3.1	Location	97
4.3.2	IEQ measurements	97
4.3.3	Recruitment procedures	97
4.3.4	Ethical approval	102
4.3.5	Statistics	102
4.4	Results	103
4.4.1	Participants, general health and OSDI score by gender	103
4.4.2	Visual acuity and staylight	104
4.4.3	Occupational perception by gender	105
4.4.4	Occupational perception by OSDI Group	106
4.4.5	Individual light control at workstation	107
4.4.6	Social impact of eye or building-related problems	108
4.4.7	Individual light control at workstation	108
4.4.8	Social impact of eye or building-related problems	108
4.4.9	Environment	110
4.5	Discussion	110
4.5.1	Impact on worker well-being	114
4.5.2	Limitations	115
4.5.3	Practical Implications	115
4.5.4	Conclusion	116
4.6	Next step	116
5	INVESTIGATING CLINICAL SIGNS OF DRY EYE DISEASE IN A MODERN, DIGITAL OFFICE ENVIRONMENT	117
5.1	Introduction	117
5.2	Aim	119
5.3	Methods	119
5.3.1	Recruitment procedures	119
5.3.2	Ethical approval	120
5.3.3	Clinical investigation	120
5.3.4	Statistical analysis	122
5.4	Results	122
5.4.1	Demographics	122

5.4.2	General and ocular health	122
5.4.3	Ocular symptoms at time of the examination	124
5.4.4	Experienced symptoms at time of examination vs OSDI score	124
5.4.5	Experienced symptoms at time of examination vs clinical signs	125
5.4.6	OSDI score	125
5.4.7	Clinical outcome on tear film, and eye and adnexa	125
5.4.8	Correlation between clinical tests and clinical signs	127
5.4.9	Clinical outcome and referrals	128
5.5	Discussion	130
5.5.1	Limitations	134
5.6	Conclusion	136
5.7	Next step	136
6	AGREEMENT IN DRY EYE DISEASE CARE MANAGEMENT BETWEEN GENERAL PRACTITIONERS (GPS) AND OPTOMETRISTS IN THE NETHERLANDS	138
6.1	Introduction	138
6.2	Aim	139
6.3	Methods	139
6.3.1	Survey Design	140
6.3.2	Recruitment	140
6.3.3	Ethical approval	141
6.3.4	Statistical methods and analysis variables	142
6.4	Results	142
6.4.1	Patient numbers	143
6.4.2	Use of Dry Eye Questionnaire	143
6.4.3	Symptoms for dry eye	144
6.4.4	Causes of dry eye disease	146
6.4.5	Reasons for developing dry eye	147
6.4.6	Use of investigative techniques	149
6.4.7	Prescribed treatment	150
6.4.8	Knowledge of recent research on dry eye disease	150
6.4.9	Co-management of dry eye in primary healthcare	151
6.5	Discussion	153
6.5.1	Limitations	159
6.6	Conclusion	159
6.7	Next step	160
7	THE REQUIREMENTS FOR A DRY EYE MANAGEMENT HEALTHCARE MODEL FOR BY GPS, OHPS AND OPTOMETRISTS IN THE NETHERLANDS	161
7.1	Dutch Healthcare System	161
7.2	Investigation by the Delphi method	164
7.3	Objectives of the study	165

7.4	Method	165
7.4.1	Experts	165
7.4.2	Inclusion criteria	166
7.4.3	Delphi Method	166
7.5	Preparation of Surveys	167
7.6	Method; Delphi Round 1	168
7.7	Method; Delphi Round 2	169
7.8	Method; Delphi Round 3	170
7.9	Data collection and protection	170
7.10	Results	171
7.11	Round 1: Impact on visual functioning and daily activities from DED symptoms	171
7.12	Knowledge, diagnosis and management	173
7.13	Healthcare insurance	173
7.14	Who will be or can be the specialist in primary dry eye care?	175
7.15	Wishes and needs, open question	175
7.15.1	Optometrists	175
7.15.2	OHPs	176
7.15.3	GPs	177
7.16	Professional role in a care system	178
7.17	Concluding Delphi Round 1	179
7.18	Delphi Round 2	180
7.18.1	Optometrists and OHPs opinion: Position of optometrists in primary care	181
7.18.2	Optometrists and OHPs opinion: Optometrists leading in management	181
7.19	Optometrists and OHPs opinion: Knowledge of DED	182
7.20	Optometrist and OHP opinion: Optometric skills	182
7.20.1	Optometrists opinion: New healthcare pathway	182
7.20.2	Optometrists opinion: Wishes and needs of optometrists	183
7.20.3	OHPs opinion: Position of optometrists in primary care	184
7.20.4	OHPs and GPs opinion: Optometrists as a supplement in primary healthcare	184
7.20.5	GPs opinion: A specialised optometrist is complementary	184
7.20.6	GPs opinion: Optometrist as DED specialist	185
7.20.7	GPs opinion: Care system and specialism	185
7.20.8	GPs opinion: Need for a care coach	185
7.20.9	GPs opinion: Competency of optometrist for ABCD model	186
7.21	Delphi Round 3	186
7.21.1	Optometrists and OHPs opinion: Competency of optometrist for ABCD model	186
7.22	Delphi Round 3 Optometrists	188
7.22.1	Optometrist opinion: Scope of practice of optometry and competencies	188
7.22.2	Optometrists opinion: Innovative	188
7.22.3	Optometrists opinion: Skills and care	188

7.22.4	Optometrists opinion: Conclusions on the ideal situation	189
7.23	Delphi Round 3 OHP	189
7.23.1	OHPs opinion: Needed communication between OHP and optometrist	189
7.23.2	OHPs opinion: Conclusions on the ideal situation	190
7.24	Delphi round 3 GPs	190
7.24.1	GPs opinion: Conclusions on the ideal situation	190
7.25	Discussion	191
7.25.1	Values/Ethics for Inter-professional Practice	192
7.25.2	Roles/Responsibilities	192
7.25.3	Inter-professional recognition and communication	194
7.25.4	Competency team and teamwork; Professional insecurity	195
7.26	Limits	196
7.27	Recommendations	197
7.28	Conclusion	198
8	GENERAL DISCUSSION	199
8.1	Office-related dry eye	199
8.1.1	Conclusion: Office workers are vulnerable for DED	202
8.2	Primary Healthcare for work-related DED	202
8.3	Recommendations	205
	REFERENCES	209
1.	Appendix Overview questions asked by survey A	228
2.	Appendix 2 Overview questions asked in survey B	229
3.	Appendix 3 Published Articles	230

IV. List of Figures

Figure 1-1	The International Classification of Functioning (ICF) model.	22
Figure 1-2	Mind map of DED, care system, impact and risks factors.	23
Figure 2-1	Causes of dry eye disease (from DEWS Report, 2007). ¹²	27
Figure 2-2	Summarised mechanism of dry eye disease (from DEWS Report, 2007). ¹²	28
Figure 2-3	Diagram of the processes involved in thinning of the tear film (from Wolkoff al, 2005). ³	30
Figure 2-4	Cellular reaction to elevated tear osmolarity.	42

Figure 2-5 In vivo meibography	45
Figure 2-6 Dry eye severity scheme, modified from the DEWS Report 2007.	52
Figure 2-7 Users of prescribed artificial tears per age group (2015) (Gipdatabank.nl, 2015).	53
Figure 2-8 Work placements of optometrist member of the OVN 2012	57
Figure 2-9 The Chronic Care Model, developed by the MaColl Institute.	60
Figure 2-10 ICF classification by the World Health Organisation (WHO) 2001.	66
Figure 2-11 The ICPC-2 as designed by the World Organisation of Family Doctors (WONCA) International Classification Committee (WICC).	67
Figure 3-1 Symptoms experienced at work and at home in percentage of the participants of all 3 locations	82
Figure 4-1 Flowchart investigation	98
Figure.4-2 Distance VA of subjects for right eye (OD) and left eye (OS)	104
Figure 4-3 Near VA of subjects for right eye (OD) and left eye (OS) with habitual correction	105
Figure.4-4 Distribution of Straylight measurement outcome and age.	105
Figure 4-5 Social impact Social impact of eye or building-related problems.	109
Figure 5-1 Clinical assessments completed on each subject.	121
Figure 5-2 Outcome of TBUT and PRT test worst eye.	126
Figure 5-3 OSDI group PRT and TBUT worst eye.	127
Figure 5-4 Reasons for referral.	129
Figure 6-1 The use of dry eye questionnaires by optometrists and GPs'.	144
Figure 6-2 Percentage agreement for dry eye symptoms indicated by optometrists.	145
Figure 6-3 Percentage agreement for dry eye symptoms indicated by GPs.	146
Figure 6-4 Causes of development of dry eye reported by optometrists.	147
Figure 6-5 Causes of development of dry eye reported by GPs.	147
Figure 6-6 Percentage agreement in reason for developing dry eye indicated by optometrists;	148
Figure 6-7 Percentage agreement in reason for developing dry eye indicated by GPs;	148

Figure 6-8 Percentage agreement for use of investigative technique, indicated by optometrists;	149
Figure 6-9 Percentage agreement for use of investigative technique, indicated by GPs;	150
Figure 6-10 Prescribed treatment by optometrists, AT=Artificial tears.	151
Figure 6-11 Prescribed treatment by GPs, AT=Artificial tears.	151
Figure 6-12 Percentage agreement for knowledge of the DEWS Report indicated by GPs and optometrists.	152
Figure 6-13 Percentage agreement for knowledge of the MGD Workshop Report indicated by GPs and optometrists.	152
Figure 7-1 Schematic diagram of the 4 healthcare domains in the Kaljouw Report ABCD model (2015).1	162
Figure 7-2 The chronic care model, as developed by Edward Wagner (1990).	163
Figure 7-3 Outline of the three rounds used in the Delphi survey.	168
Figure 7-4 Mean rank of the possible influence of symptoms on work productivity,	172
Figure 7-5 Mean rank of the possible influence of symptoms on visual functioning during the working day	172
Figure 7-6 Professionals answer to their role in healthcare	179
Figure 7-7 Agreement at optometrist panel	179
Figure 7-8 Agreement at OHPs panel	180
Figure 7-9 Agreement at GPs panel	180
Figure 7-10 Opinion of optometrists about optometry education and the role and knowledge of the optometrist in general healthcare.	182
Figure 7-11 Optometrists wishes and needs for dry eye management in primary healthcare;	183
Figure 7-12: Each profession's opinion on Competency of optometrists in primary care.	187
Figure 7-13: Each profession's opinion on Competency of optometrists in public health	187
Figure 8-1 The problem at the heart of the office.	201

V. List of Tables

Table 2-1	Categorisation standards for NEN–ISO-7730	32
Table 2-2	Diagnostic tests and diagnosis criteria	44
Table 2-3	Schaumberg symptoms-based three question questionnaire.	48
Table 2-4	Of the Schaumberg symptoms based questionnaire, three DED categories were formed.	49
Table 2-5	Prevalence of dry eye using the Schaumberg questionnaire (Schaumberg 2003).	49
Table 2-6	DED prevalence and incidence using the symptom-based Scheim questionnaire.	50
Table 2-7	Differences between patient-centred care and person-focused care.	61
Table 2-8	Competencies for inter-professionality	64
Table 2-9	Incidence and Prevalence eye and adnexa disease NIVEL 2015 (21-06-2017)	68
Table 3-1	Survey A, Demographics data of participants.	78
Table 3-2	Survey B: Demographics data of participants.	80
Table 3-3	Comparison of experienced eye symptoms during the working day and at home.	81
Table 3-4	Work productivity and activity index outcome	83
Table 3-5	Illness perception questionnaire	84
Table 3-6	Symptoms experienced at work vs home per location.	85
Table 3-7	Demographic data per location of survey A	86
Table 3-8	Environment perception per location.	88
Table 4-1	Set of questions; Ocular history, General health	99
Table 4-2	Set of questions; perception and impact of eye-related problems	101
Table 4-3	Comparison of satisfaction of IEQ between each OSDI Group, and difference in score: Group A – Group B.	107
Table 4-4	NEN-7730:2005 limits for offices.	110
Table 5-1	Set of questions; Demographics data of participants	123
Table 5-2	Symptoms experienced at eye examination	124

Table 5-3 OSDI score per gender and OSDI Group I and II.	125
Table 5-4 Correlation between experienced eye symptoms at examination and clinical tests and signs.	125
Table 5-5 Correlation clinical tests and signs.	128
Table 5-6 Comparison between OSDI Group for eye exam details.	129
Table 6-1 Survey questions investigating knowledge, investigative methods, therapy preference and experience of GPs and optometrists.	141
Table 6-2 Demographic data of patients seen per week .	144
Table 7-1 List of questions asked in Round 1, with their mean Likert score for each profession.	174

VI. Abbreviations

ABCD model: Future care in for Domains in the Netherlands

ANOVA :Analyses of Variances

FBUT: Fluorescein Break Up Time
GIP: Genees- en hulpmiddelen Informatie Project
GP: General practitioner
HAP: Huisartsenpost, GP services out-of hours
ICF: The International Classification of Functioning
ICPC: International Classification of Primary Care
IEQ: Indoor environmental quality
IPC: Inter-professional Cooperation
IPEC: Inter-professional Education Collaborative
IPE: Inter-Professional Education
IPQ: Illness Perception Questionnaire
KCS: Kerato-conjunctivitis sicca

OVN: Optometry Association Netherlands

QoL: Quality of Life

PCC: Patient-centred care

PFC: Person-focused care

PPM: parts per million

PRT: Phenol red thread test

RH: Relative Humidity

SAS: Self-rating Anxiety Scale

SBS Sick Building Syndrome

SDS: Self-rating Depressing Scale

SD: Standard deviation

TTT: Tear Thinning Time

TMH: Tear meniscus height

VA: Visual acuity

VDT: Visual Display Terminal

ZVW: Zorgverzekeringswet

WCO: World Council of Optometry

WECS: Wales Eye Care Services

WHO: World Health Organisation

WHS: Women's Health Study

WICC: WONCA International Classification Committee

WPAI: Work Productivity and Activity Index

WONCA: World Organisation of Family Doctors

WICC: World International Classification Committee

ZWW: Zorgverzekeringswet

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1 Introduction

*Health is a state of **complete physical, mental and social well-being** and not merely the absence of disease or infirmity.* World Health Organisation (1948).

The purpose of this thesis is to 1) investigate the need for a change in the primary healthcare system for mild-severe dry eye in the working age population in the Netherlands, who are working in office buildings with highly-demanding visual tasks; and, 2) to consider what kind of care system would be most suitable to enhance patient care.

Dry eye disease (DED) is an ocular surface disease produced by deficiencies in the quality or quantity of the tear film. Diagnosis is based on a combination of patient symptoms and clinical signs, and treatment is palliative at best. Chronic dry eye adversely affects a patient's quality of life, and leads to a high, illness perception, with increased anxiety or depression at its most debilitating level. Worldwide, there is considerable research into DED, with much progress over the last 10 years. The publication of the Dry Eye Workshop (DEWS) I and II and the Meibomian Gland Disease (MGD) Workshop Reports, has produced a stronger focus on investigations in basic and clinical research of clinical relevance. The workshops have also encouraged a greater focus on research that provides evidence of the cultural impact of DED.

Nevertheless, DED research has mostly searched for the answer of why it occurs, what are the correct diagnostic methods to use, and what is the best evidence for the use of therapeutics for these patients. The treatment options for DED are primarily-focused on diminishing the subjective complaints of dry eye symptoms, or on the objective signs, such as corneal staining, by improving the quality and quantity of the tear film. However, there is a large imbalance in the number of published investigations towards pharmaceutical treatment-based science, and away from the mental and psycho-social impact of DED and the role of the eye care professionals in the treatment process.

The economic burden of DED is considerable. In 2010, the cost of prescribed artificial tears in the Netherlands was in excess of €22million, and this does not include the cost of practitioner time or over-the-counter artificial tear sales. However, there is limited knowledge of the cultural impact of dry eye in the Dutch population; additionally, there is no information available about the prevalence or management of dry eye patients in the Netherlands. Aging is considered to be the main reason for developing dry eye, but with the move towards paperless office-work, in buildings with a controlled climate, there is an increasing group of people developing dry eye earlier. Moreover, with the lengthening of the age of retirement to 67 years, there could be a magnifying combination of age-related dry eye with work-related dry eye. These changes suggest that there is a need for more focus on a multi-disciplinary care system, looking at screening, prevention and management of dry eye symptoms during the working years.

Concurrent with these changes in work practice, and potentially in DED incidence, the Dutch government has undertaken a review of its overall healthcare system structure, with an emphasis on embedding multi-disciplinary clinical care pathways as the fundamental approach to patient-centred care. The aging population and the increasing cost of healthcare has forced the government to move towards an integrated care system, with a focus on good care that is cost-effective. This will mean a re-distribution of patients to where the clinical skills are, and the best way to reduce costs is to manage as many diseases as possible in primary healthcare.

Patient-centred care is a model of care that places the individual patient as central to their care. One example of this is the International Classification of Functioning (ICF) model (Figure 1.1). This model looks at how activities, such as work, are affected by various factors – the disease itself, the body site, what is the desired activity – and how personal and environmental factors influence this. Personal factors include age, gender, social background, past experiences, character and habits, and also education and profession. The environmental factors are broader than just the natural environment, but also

include human-made changes, such as the office working environment, and the social environment of the individual for support and relationship. In this way, contact with a therapist or care provider can fall within the environmental factors.

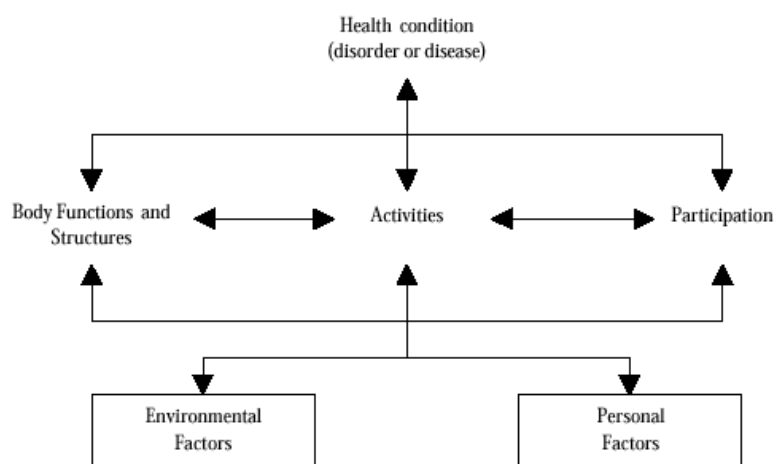


Figure 1-1 The International Classification of Functioning (ICF) model.

By applying the ICF model to DED, a mind-map (Figure 1.2) can be used to show the factors that influence the care given, the known risk factors, and the influence from daily activities on dry eye patients. This shows the complexity of treatment that may be required, and so helps with awareness of the need for a patient-centred, multi-disciplinary approach. However, the need for, and the possible structure, of an inter-disciplinary care system for DED has not been investigated.

In the mind map, self-management is not connected to the others. This is because self-management is a topic on its own, and is broader than just buying and using over-the-counter artificial tears. Self-management is complicated to define, since it involves the educational background of the patient, combined with their capability and skill in understanding and taking care of their disease. Self-management can be influenced by commercially-guided messages in primary healthcare. For DED, the question could be raised of who should be the healthcare professional who acts as the educator for these patients?

Within this broader context, it is clear that any new care pathway for DED must

follow an individualised approach, that is embedded in a care system that meets the WHO definition of health, the economic realities of the government, and the competencies of primary healthcare professionals.

The optometrist has a significant role in primary healthcare, providing diagnostic and treatment services in eye care. Although optometric care is an individualised service, this is not necessarily a good thing, since optometrists are often isolated in their practice and are not part of a multi-disciplinary team.

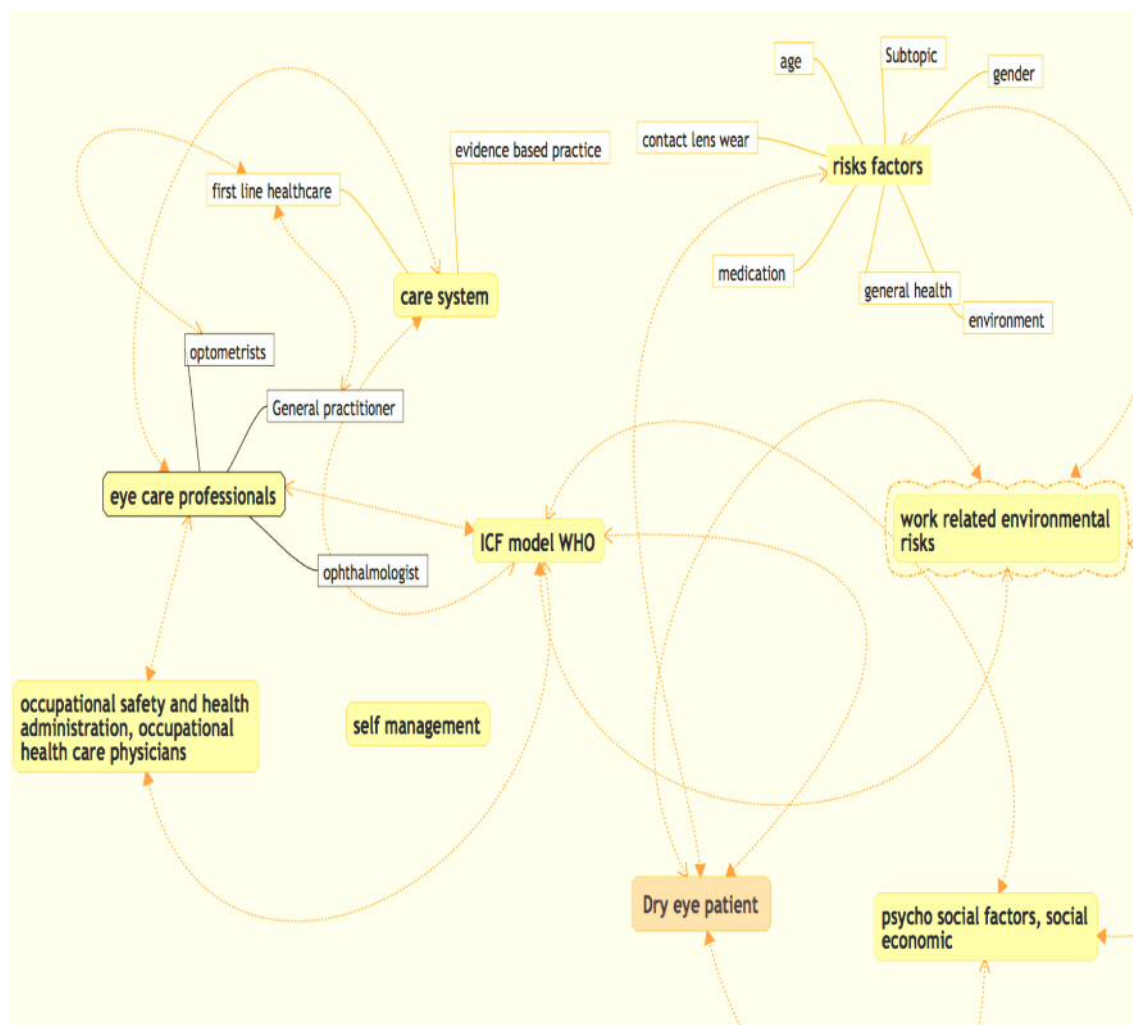


Figure 1-2 Mind map of DED, care system, impact and risks factors.

Thus, the optometrist is a good example of a primary healthcare professional, with specialist skills, who may not be known by other healthcare practitioners. Dry eye management could be done by an optometrist who has specialist skills, but there is some evidence that the optometrist is not aware of all the factors

involved with DED. Nor is it clear that other primary healthcare professionals have sufficient knowledge of the possible impact of dry eye on daily activities, or of the patient-centred influences on dry eye.

There is evidence of a need for better dry eye management for office workers, and there is an opportunity to develop a clinical care pathway for DED as part of the Dutch revision of healthcare provision. To address this, there is a need to:

- Investigate if office workers are a more vulnerable group of individuals to environmental influences on their dry eye symptoms during daily activities at work, and whether they experience negative influences on their social life.
- Understand the current opinion of healthcare professionals on their role in managing DED.
- Find consensus between primary healthcare professionals for a preferred treatment plan for dry eye patients to improve detection, reduce risk factors, relieve symptoms, and improve access.
- Establish an action plan for developing a care pathway for DED.

2 Literature Review

2.1 The Tear Film

The tear film performs several functions: it assists in producing a good optical quality at the retina by smoothing the irregular surface of the cornea, and any disturbance in its structure can cause visual disturbances.^{1,2} It lubricates the anterior segment of the eye, it nurtures the avascular cornea, and it protects the exposed ocular surface from environmental risks between blinking.^{3,4}

The tear film, also called the pre-corneal layer, is structured into a complex, multi-layer, thin film. The most superficial layer is the lipid layer, secreted from the Meibomian glands located in the superior and inferior eyelids.⁵ The lipid layer protects the aqueous layer from evaporation.^{6,7} The aqueous layer of the tear film, secreted by the lacrimal and accessory glands provides nutrition and oxygen to the cornea, and it defends the anterior eye surface against infection.^{5,8} The cornea and aqueous layer are “connected” by the mucous layer, which is secreted from the conjunctival goblet cells and surface epithelial cells.^{9,10}

The tear film protects the anterior surface by helping to remove foreign bodies and any infective agents. This is called the first line of defence.⁹ A foreign body or organism will be coated by mucin, and, by the blinking force, transported to the nasal eyelid puncta where they are expelled.¹¹ The response from the immune proteins of the aqueous layer is called the second line of defence, and the cornea itself acts as a barrier to micro-organisms, so long as the corneal epithelial cells are intact. This is the third line of defence.⁸

Any interference in the relationship between the tear film and the ocular surface has an impact on the performance of these roles, and will lead to ocular surface damage and symptoms, such as discomfort, visual disturbance or tearing of the eye. The causes and consequences of any such interference have been grouped together under a broad definition of ‘dry eye disease’.¹²

2.2 Definition of Dry Eye Disease (DED)

Dry eye disease (DED) has received considerable worldwide research attention. The terms 'dry eye', 'dry eye disorder' and 'dry eye disease' are often used synonymously, and the definition of dry eye has been widely-debated. The two main definitions have arisen from two multi-disciplinary workshops gathered to discuss the topic.

The 1995 National Eye Institute (NEI)/Industry Dry Eye Workshop gave the definition as: *“Dry eye is a disorder of the tear film due to tear deficiency or excessive evaporation, which causes damage to the inter-palpebral ocular surface and is associated with symptoms of ocular discomfort”*.¹³

This was revised by the 2007 Dry Eye Workshop (DEWS) to: *“Dry eye is a multifactorial disease of the tears and ocular surface that results in symptoms of discomfort, visual disturbance, and tear film instability with potential damage to the ocular surface. It is accompanied by increased osmolarity of the tear film and inflammation of the ocular surface”*.¹²

This latter definition has become the most widely-accepted definition, and it emphasises that patient symptoms are also important in the disease process. A new update on DED, called DEWS II, with a revised definition will be published in mid-2017.

For mild to moderate dry eye, DED is primarily considered as a symptom-based condition, since clinical signs can be limited or inconsistent at this stage.

However, even then, patient-reported dry eye symptoms may not be reliable and may vary due to sensory damage of the ocular surface.^{14,15} Reported symptoms can include all of the following; burning of the eyes, ache, watery eyes, Foreign body sensation, dryness, discomfort or irritation of the eye, grittiness and itching/ stinging of the eyes. But also other symptoms as foreign body sensation, tiredness, ocular fatigue, photophobia, blurring (fluctuating) sticky tears, conjunctival redness, swollen, red eyelids, soreness and pain.¹⁶

The major grouping of aqueous-deficiency dry eye includes Sjögren's syndrome

dry eye and non-Sjögren's syndrome dry eye. Sjögren's dry eye is divided into primary Sjögren's, caused by inflammation in the lacrimal gland due to autoimmune disease, and secondary Sjögren's. Secondary Sjögren's has the same impact on DED symptoms, but the cause of the disease is from another autoimmune disease (Figure 2-1)¹⁷

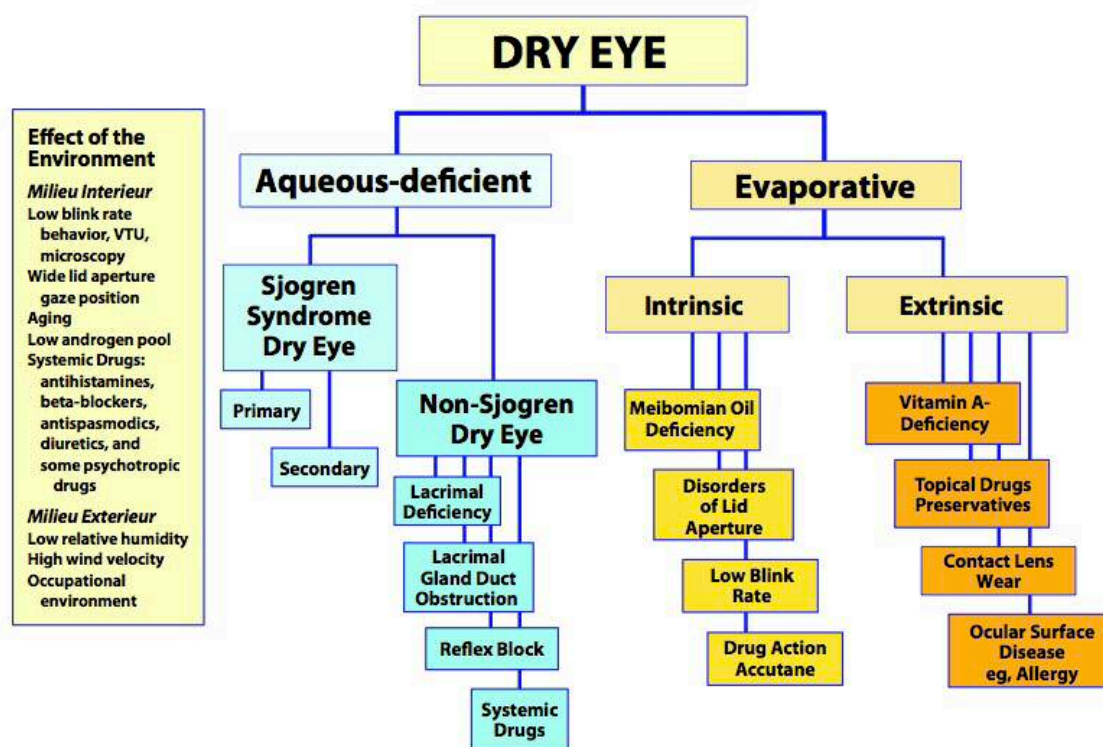


Figure 2-1 Causes of dry eye disease (from DEWS Report, 2007).¹²

Evaporative dry eye can be caused by problems in the production and delivery of lipids to the tear film (intrinsic) or by circumstances that increase instability of the tear film and promote evaporation (extrinsic).^{7,18}

Meibomian gland dysfunction (MGD) is a major cause for developing an unstable tear film, resulting in dry eye. The 2011 Workshop on Meibomian Gland Dysfunction¹⁸ gave this definition: "*Meibomian gland dysfunction (MGD) is a chronic, diffuse abnormality of the meibomian glands, commonly characterised by terminal duct obstruction and/or qualitative/quantitative changes in the glandular secretion. It may result in alteration of the tear film, symptoms of eye irritation, clinically apparent inflammation, and ocular surface disease*".

The mechanism of dry eye is summarised in Figure 2-2. One of the core mechanisms in developing dry eye symptoms is tear hyper-osmolarity. This is the consequence of a high evaporation rate from the tear film or a low lacrimal flow. Furthermore, high evaporation can occur by having a compromised lipid layer due to MGD. Environmental factors, such as high air speed or low humidity, can be an exacerbating factor, promoting dry eye symptoms, such as burning or tearing of the eyes. An unstable tear film and tear hyper-osmolarity can lead to chronic epithelial stress and symptoms of ocular irritation, resulting in (corneal) inflammation and triggering a response from the ocular surface sensory neurons.^{10,19}

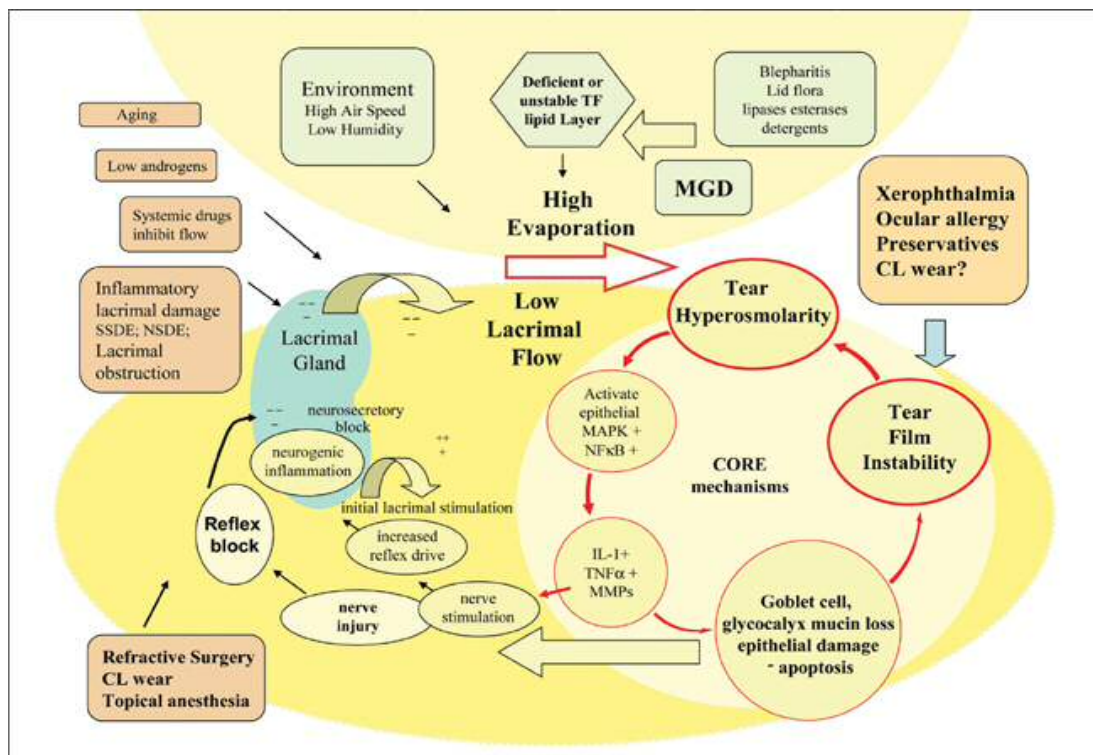


Figure 2-2 Summarised mechanism of dry eye disease (from DEWS Report, 2007).¹²

2.2.1 Impact of blinking

Several researchers have investigated the impact of blink frequency during specific tasks, such as reading or computer work, and have shown that the position of the monitor influences blink frequency.²⁰ Blink frequency decreases while reading from a computer screen by 2-3 times. This makes the cornea less protected from environmental issues, especially when looking straight ahead at the computer monitor. The DED reduction in the tear break-up time (BUT) will

lead to an unstable tear film during reading from a computer screen.^{3,21,22} The wide-open lid aperture can be reduced by getting the patient to look downwards towards a computer monitor that is placed in the lower field of view. There is a need to raising awareness in DED patients, and in healthcare professionals, of having the right viewing distance and visual angle when using a computer screen.^{23,24}

The ocular protection index (OPI) is a way to assess the interaction between blinking and the BUT.²⁵ The index describes corneal protection as it relates to blink frequency. By suppressing blinking, the cornea becomes more exposed to the environment (Figure 2-3). The OPI can also be used to show whether a change in blinking frequency will lead to a break-up in the tear film before the next blink occurs.

Blink-rate is task dependent for both dry eye and non-dry eye patients.²⁶ What is important is the level of concentration needed for a specific test, which can slow the blink-rate, leading to an increase in dry eye symptoms and corneal staining.²⁶ A suppressed blink frequency, combined with a short break-up time, may lead to a deterioration in optical quality, and has been demonstrated to create a similar effect to dry eye on visual performance.²⁷

The impact of computer use on the function of the lacrimal gland is not clear. Nakamura et al. (2010) suggested that the time spent using a visual display terminal (VDT), and the number of working years, is associated with hypo-function of the lacrimal gland.²⁸ The direct roles of the reduced blink-rate and any hypo-function of the lacrimal gland are unclear.²⁸

The association between dry eye symptoms and working with a computer monitor is generally accepted on the work-floor, as well as in research. Symptoms of DED are associated with an adverse impact on vision-related quality of life, the performance of daily activities, the ability to work, and emotional well-being,^{29,30} even for mild/moderate dry eye.³¹

affect visual functioning during computer tasks.^{35,36,32}

2.2.3 Indoor environment standards

In the Netherlands, the ISO Standard for Ergonomics of the Thermal Environment (NEN-ISO-7730:2005)¹ (based on theoretical and empirical studies) is used to standardise the measurement of the general thermal sensation and degree of comfort for workers. The thermal environment is described as the personal expression of satisfaction with specific aspects of the environment, including air temperature, radiant temperature, air velocity, humidity, clothing and activity. The international standard was specifically developed for the work environment, and other references are used for the need of people with special needs, such as physical disabilities.

When testing the indoor climate, the following climate standard conditions are considered: indoor temperature, ventilation air stream, air humidity, and carbon dioxide (CO₂). Acceptable air quality standards are used to categorise the building as: A, very good; B, good; C, acceptable (Table 2-2). For relative humidity (%), 'very good' means a relative humidity range between 30-50%, 'good' between 25-60%, and 'acceptable' between 20-70%. A 'good' indoor temperature in the summer is within 23-26°C, and in the winter is within 20-24°C (Table 2-1).

However, Yokoi et al. (2015) stated that, despite the indoor environment in buildings complying to the standard of being within "acceptable air quality standards", it is very likely that some of the workers in these buildings suffer from unrecognised DED.³⁷

¹ ISO 7730 (2005) Ergonomics of the thermal environment—analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria

Table 2-1 Categorisation standards for NEN–ISO-7730

NEN 7730 category	A) Very Good	B) Good	C) Acceptable
Indoor temperature (°C)	Summer: 23 - 26 Winter: 20 – 24	Summer: 23 - 26 Winter: 20 - 24	Summer: 22 – 27 Winter: 19 – 25
Air humidity (%)	30 – 50	25 - 60	20 - 70
Air Stream (m/s*)	Summer: <0.12 Winter: <0.10	Summer: <0.19 Winter: <0.16	Summer: <0.24 Winter: <0.21
Carbon dioxide (CO₂) (ppm**)	<500ppm	<900 ppm	<1100 ppm
*m/s: meters per second; **ppm: particles per minute			

2.3 Work-related DED

It is known that, when working on a desktop computer, the worker will have a decreased blink-rate, which leads to reduced tear stability, and can produce increased evaporation of tears from the exposed ocular surface. When this occurs in an office environment with a low relative humidity (RH <40%) and/or an air draft (1.5m/s), it can cause an even higher evaporation rate from the tear film.³⁸ This is often called the ‘desiccating stress of the eyes’. In turn, this desiccating stress leads to increased tear instability, which promotes further evaporation, and a recurring cycle of tear instability, evaporation and surface desiccation.³⁹

This stress cycle initiates an inflammatory process that will produce symptoms, cause damage to the anterior surface of the eye (cornea and conjunctiva), and decrease the production rate of tears. Individual workers can also have other ocular pathologies which can contribute to the reduction in tear stability or production. For example, blepharitis (an eyelid margin disease) is more often seen in people in areas with air pollution, and it is thought that indoor air determinants or pollution of the indoor air can promote its development or increase its severity.⁴⁰

Since subjective symptoms and clinical signs do not correspond well with

objective measurements in the diagnosis of DED,¹⁶ and observation of the clinical signs takes place in a different setting from their workplace, the consequence can be un-intended mis-diagnoses of work-related DED. It is important to understand that symptoms, such as burning, dryness, gritty, itchy and stinging sensation, as well as scratchiness, soreness, blurry vision, strain and eye irritation or asthenopia, need to be associated with the work-related environment,⁴¹ since workplace humidity and air temperature, and the presence of an air-draft, are thought to be significant influences on the development of the signs and symptoms of DED.^{38,39}

In the published literature, work-related DED symptoms often fall under the diagnosis of Sick Building Syndrome (SBS), which includes a group of symptoms of unclear aetiology.⁴² As far back as 1984, the World Health Organisation (WHO) reported that workers in up to 30% of new and re-modelled buildings worldwide complain about poor, indoor air quality.^{33,35} The symptoms experienced are often grouped under the broad title of Sick Building Syndrome (SBS), which is only used when the symptoms are related to the building environment and which disappear after leaving the building.^{42,43} It is important to recognise that SBS can cause absence from work and will impact work productivity. Symptoms are divided into mucous membrane symptoms (related to the eyes, nose, and throat), and dry skin and general symptoms (headaches and lethargy).⁴² The symptoms are similar if they are age-related or work-related with one difference, that the symptoms at work could be more intense than at home.

For modern office buildings, poor air quality has a strong relationship to dry eye symptoms, tiredness of the eyes and irritation.⁴⁴ The workplace environment has a negative influence on tear meniscus height (TMH) and the effectiveness of dry eye treatment.^{38,39} It is also noted that females are more vulnerable to having eye-related symptoms linked to SBS.⁴⁵

Eye problems associated with the office environment can also be divided into binocular vision-related eye problems, such as eye-strain, double vision or tired eyes, and ocular surface-related problems, primarily caused by an unstable tear

film, producing symptoms of irritation, burning sensation or dryness.⁴⁶ Computer Vision Syndrome (CVS) or Dysfunctional Tear Syndrome (DTS) are commonly-used terms for specific eye-related problems that occur while using a computer. Dry eye symptoms and asthenopia complaints occur more frequently when using electronic devices. CVS is a combination of eye and vision problems, which may include eyestrain, headache, ocular discomfort, dry eye, diplopia, and blurred vision.⁴⁷ It is believed that computer work causes eyestrain, promotes a reduction in blink-rate, reduced tears stability and can be indirectly responsible for dry eye symptoms in the subject. DTS is associated with mild irritation, itching, redness and intermittent tearing after extended staring at a screen with the use of a computer.⁴⁸

In general, it can be said that visual symptoms associated with computer-use occur frequently in the general population. They are strongly associated with ocular surface disease and produce discomfort for extended periods of time.⁴⁹ For work-related DED symptoms, preventing the development of symptoms is preferable as recent studies show that younger persons also frequently suffer from DED.⁵⁰⁻⁵³

2.3.1 Vision-related impact of DED

Dry eye symptoms are a disorder that reduces visual functioning.^{50,54} Visual functioning is related to the ability of an individual to perform visual dependent tasks, such as reading and computer work, driving or watching television, or playing more intense video games.⁵⁵ Significantly increased symptoms of blurred vision during reading occur when reading from a computer screen vs reading from a hard copy^{56,57}.

Pathologic tear film irregularities are known to significantly affect the light pathway.¹ However, thinning of the tear film alone cannot explain patient experiences of visual disturbance or reduction in visual function. DED with central corneal staining produces a significant worsening of visual functioning compared to DED without staining, or compared to normal eyes.⁵⁸ In any case, a reduction in visual functioning, commonly manifested as blurred vision and

glare, is difficult to measure objectively.

A reduction in visual function can impact patient quality of life (QoL) widely, even though the best-corrected visual acuity (VA) is considered normal with standard charts.² One challenge with using VA as a measure of visual performance, is that, most of the time, it is performed in a controlled situation, under controlled lighting and with high contrast optotypes. In any case, VA is not a measure of visual functioning.⁵⁰

A diurnal difference in visual functioning may be a factor to consider when looking at mild/moderate DED. Walker et al. (2010) found that visual functioning in DED is reduced in the evening, maybe as a result of a compromised tear film and increased staining seen in the evening. However, the study had no control groups, leaving no reference to normal changes during the day.⁵⁰

The impact of computer-work, and its impact on blink-rate seems to be associated with the time spent on the computer.²⁸ Portello et al. (2013) concluded that the management of work-related ocular surface disease, or more general DED symptoms, should include therapeutic regimens that are less common, such as a practical implementation of blinking exercises during computer-work.⁵⁹

2.3.2 Contrast sensitivity, glare and glare disability

It is known that DED affects the quality of visual functioning, with the most common complaint being blurred vision. For example, significant complaints can occur after only 2 hours of computer work.⁵⁶ Blurred vision, and also light sensitivity, have been investigated in relation to DED, but VA is not specific enough to detect visual function problems with DED. Contrast sensitivity, higher order aberrations and straylight measurements are better methods to investigate the visual disturbance DED patients experience. In several investigations, contrast sensitivity, with and without the presence of glare, was found to be significantly decreased in dry eye patients compared with non-dry eye subjects.^{60,61}

Disability glare is defined as that glare which causes a decrease in VA or contrast sensitivity.⁶⁰ In the literature, glare is produced by an external light source, which can cause disability glare. Disability glare can also be called 'straylight', which causes a reduction in the contrast of the retinal image. Straylight measurement can give information about the quality of vision, in addition to contrast sensitivity measurements and slit-lamp evaluation. In the latest studies, a decrease tear film stability seems to produce a greater increase in straylight than corneal surface staining. A decreased tear film stability could combine with changes in the normal aging eye to increase straylight measurements.^{58,62}

In the Netherlands, straylight measurement is done using the C-Quant instrument (Oculus, Amsterdam, The Netherlands), developed by TJTP van den Berg. Currently, straylight measurement is not a standard procedure for DED patients.

2.3.3 Higher order aberrations

An unstable tear film can cause irregularity in the optical system, reducing the normal smoothing of the corneal surface by the tear film. In one study, an increase in higher order aberrations has been measured in DED patients due to tear film irregularity.⁵² However, the criteria for defining a DED patient was that they had a BUT of less than 5 secs. Since the criteria for measurement of the aberrations requires that the subject keeps their eyes open for as long as they can, and the measurements can take 5 to 10 secs after blinking, the DED subject will experience a more unstable tear film than would occur for a patient with a stable tear film. In contrast, Ridder et al. (2009) found no significant difference in high order aberrations between DED patients and patients without symptoms.⁶³

2.4 Dry eye and Quality of Life

DED can develop due to an auto-immune disorder, environmental factors or medication, and changes in any of these factors can increase symptoms. This implies that DED must be considered as a multi-factorial disease. However, the

lack of clinical damage of ocular tissue in mild and moderate dry eye means that treatment is often based on symptom relief.^{48,64}

There is evidence that the quality of life (QoL) is compromised with severe DED. It has even been said that measuring the QoL would be a valuable diagnostic measurement in assessing the burden of DED.⁶⁵ Friedman suggested that a measurement of QoL should be integrated into clinical practice and future trials.⁶⁵ Even with the visual functioning questionnaire (NEI VFQ-25), the impact of DED on visual functioning showed a correlation between signs and symptoms, even when there was no correlation with the diagnostic test outcome. Similarly, when the tear film break-up time and fluorescein staining score showed no signs of dry eye symptoms, the complaints of pain were reflected in the VFQ-25 score.²⁵⁴

Garcia et al. (2009) suggested that the Ocular Surface Disease Index (OSDI) questionnaire would be more specific than the VFQ-25. Their study showed that both questionnaires were adequate for assessing the QoL of DED patients.⁶⁶ An adjustment of the VFQ-25 with 14 extra dry eye specific items was used by Li et al.^{54,67} This study showed that vision-related QoL was lower for DED patients than with the healthy control group. The DED patient group was selected by patients having two or three of the following conditions:

- (1) Symptoms of dry eye and or asthenopia
- (2) Positive Schirmer test and/or BUT test for diagnosis of dry eye
- (3) Positive corneal fluorescein staining

However, this categorisation meant that participants with only subjective DED complaints were excluded from this study, since well-known complaints of DED are not captured well in the range of dry eye tests used for diagnosing dry eyes.⁶⁷ Thus, even though the VFQ questionnaire, with the extra 14 dry eye-related questions, showed the ability to assess QoL, it excluded the patients who might need the most recognition of their symptoms.

2.4.1 Impact of pain and dry eye

Pain sensation in the cornea can occur by corneal epithelial inflammation, with osmotic stress as the cause of corneal epithelial inflammation.⁶⁸ Corneal epithelial inflammation, and the inflammatory mediators released from the damaged corneal epithelial cell, is the initiating mechanism for a reaction that ends in hyperalgesia of the cornea.⁶⁹ It is also noted that tear evaporation can give a hyper-sensitivity reaction, producing corneal evaporative hyperalgesia. Either way, the dry eye sensation becomes a pain sensation.⁶⁹

Rosenthal et al. (2012) stated that all of the different pain mediators are assumed to be involved in DED.⁴⁷ They also felt that long-standing neuropathic pain may be associated with impairment of cognitive functions, depression, and anxiety. In other research, there are ideas that pre-existing depression and anxiety can enhance the transition of nociceptive pain to a chronic disease. However, pain is not measurable with the standard DED diagnostic tests.^{67,69}

Anxiety measurement can be made using different questionnaires, such as the Self-rating Anxiety Scale (SAS), and Self-rating Depression Scale (SDS).^{67,70} The OSDI includes some questions on the influence of DED on a subject's life, but conceivably not enough to use those questions as a diagnostic tool. It is an important question to ask whether depression or anxiety can occur due to having DED, and, secondly, if enough attention is being given to the complaints from individuals.⁷⁰

2.4.2 Work productivity

Work productivity loss in patients with DED was investigated by Patel et al. using an online survey.⁷¹ They found that patients with moderate and severe DED had a greater loss in work productivity than patients with mild DED. Since age is a known factor for DED, there may be an increasing effect on the incidence of symptoms as the retirement age of office workers increases⁷², with a consequent knock-on effect on work productivity and worker comfort. Moreover, for work-related DED, preventing the development of symptoms is preferable,

as recent studies have shown that younger persons also frequently suffer from DED.⁵⁰⁻⁵³

In particular, CVS is said to have an impact on occupational productivity and visual comfort, with between 64-90% of computer-users experiencing visual symptoms.⁴⁷ Computing in a flexible-working, digital environment, with highly visually-demanding reading tasks, from the use of a computer, laptop, tablet or smartphone, could increase tiredness of the eye and DED symptoms.⁷³

The review of Reddy et al. (2004) stated that DED seems to lead to: 7% of patients changing jobs; 11% cutting back on their working hours; 2–5 days off from work in a year; and patients continuation of symptoms for 191-208 days per year.⁷⁴

2.5 Diagnostic tests for dry eye investigation

Diagnosis of DED is based on a combination of subjective and objective tests to capture symptoms and clinical signs.

2.5.1 Dry eye questionnaires

Symptoms of DED are associated with an adverse impact on vision-related QoL, the performance of daily activities, the ability to work, and emotional well-being.^{29,30} To help investigate the Impact of DED on everyday life, the use of questionnaires has been recommended by several studies.^{15,65}

Quite a number of questionnaires, that attempt to capture the patient symptomology of DED, have been designed and used in clinical practice and clinical trials. Different questionnaires have been designed for different purposes, such as to diagnose DED, to evaluate symptoms, to evaluate the impact of DED on daily activities, or to monitor the effectiveness of treatment. There is no universally accepted and used questionnaire. The most well-known questionnaires in use in the Netherlands are either the Ocular Surface Disease Index (OSDI) and the McMonnies Dry Eye Questionnaire,⁷⁵ mainly because of their publicity through nationally published articles. The OSDI is the only

validated questionnaire from all questionnaires mentioned here.⁷⁶ DED questionnaires show high sensitivity and specificity for DED diagnosis.

2.5.2 Schirmer Test

The Schirmer (I) test (without anaesthesia) is used to estimate tear-flow. A strip of filter paper is placed in the conjunctival sac by folding the end of the strip over the lower eyelid margin, normally in the temporal corner of the lower eyelid. The paper strip has to be inserted for 5 mins and the extent of wetting of the strip is the outcome of the test. The Schirmer test outcome changes with increasing age, but a general cut-off for diagnosing DED is accepted as being less than 5mm of wetting in 5 mins. Reflex tearing, as a result of neural stimulation of the tear gland by the sensation of the paper strip, makes the test less repeatable.⁷⁷ Research has shown that repeatability of the test is better when the wetting is less than 5mm, indicating that test discrimination is better with more severe dry eye due to aqueous deficiency, e.g. Sjögren's Syndrome. All normal values and abnormal values of the diagnostic tests are listed in Table 2-3.

2.5.3 Phenol Red Thread Test (PRT)

The phenol red thread (PRT) test is similar to the Schirmer test without anaesthesia, and is also used to estimate tear-flow.⁷⁸ The end of a thin cotton thread is inserted into the conjunctival sac by folding it over the eyelid margin in the temporal corner of the lower eyelid. The thread is inserted for 15 secs and the extent of discolouring on the thread, due to absorption of the tears, is the outcome of the test. The PRT outcome varies with age, but, in general, an insufficient tear production is classified as <10mm of discoloured thread within 15 secs. A significant advantage of the PRT test is that it is less invasive than the Schirmer test, making it less affected by reflex tearing.^{78,79}

2.5.4 Tear Break-Up Time (BUT)

The tear break-up time (BUT) or fluorescein break-up time (FBUT) test is used to define the quality of the tear film,⁸⁰ and is a very commonly-used dry eye test. The quality of the tear film is described as the time between the last blink and the first sign of thinning of the tear film. Thinning of the tear film is shown as a

dark spot in the tear film, which is described as a 'break' in the tear film. However, it is important to note that it is not a complete break in the tear film, rather the tear film becomes thinner and the amount of soluble fluorescein in the tear film at that point reaches a concentration that makes it no longer visible to the human eye. It is suggested that using a yellow filter (Wratten filter #12) will enhance the visibility of the first "break" in the tear film, and make it easier to determine the test end-point.⁸¹ The different fluorescein patterns seen when measuring BUT can be used as an indication of the aetiology of the tear film disruption, this makes it easier to understand the underlying problem.⁸²

Sodium fluorescein (NaFl) is a dye with good solubility, and is typically delivered by wetting a dry paper strip, impregnated with the dye, and then touching the conjunctiva with the wetted paper strip. The combined dye and saline drop can de-stabilise the tear film if too much is instilled, and thereby produce dry eye values typical in normal subjects.⁸¹

2.5.5 Osmolarity Measurement

Tear osmolarity is said to be the 'gold-standard' for diagnosis of DED.¹⁰ Osmolarity describes the concentration of salts and other components dissolved in a solution. In a dry eye, the tear film contains less water, thereby increasing the relative concentration of soluble particles in the tear film. This situation is described as hyper-osmolarity.¹⁰ Tear hyper-osmolarity measurement can be produced by aqueous deficient dry eye, evaporative dry eye, or a combination of both.¹⁹

Specialised equipment is necessary to measure osmolarity in the tear film. In the Netherlands only one tear osmolarity reader, the TearLab osmometer (TearLab Corporation, San Diego, USA), is commercially available. The test does not distinguish the type of DED, and the result should be considered in conjunction with tests performed during a full clinical examination.⁸³ It has been suggested that, in moderate to severe cases of DED, the appropriate osmolarity cut-off should be a measurement greater than 312mOsm/l. In comparison, normal tears have an osmolarity of about 300mOsm/l (Table 2-2).⁸⁴

Hyper-osmolarity is known to induce apoptosis, serve as a pro-inflammatory stress factor, and reduce the ability of mucin-like molecules to lubricate the ocular surface.⁸⁵ Gilbard et al. (1994) was one of the first researchers to link tear hyper-osmolarity with apoptosis of corneal epithelial cells.⁸⁶ Also of importance is the effect of hyper-osmolarity on conjunctival goblet cells, which produce mucin that is essential for creating a stable tear film. Damaged goblet cells induce an unstable tear film, which may cause additional damage to the epithelial cells (Figure 2-4).

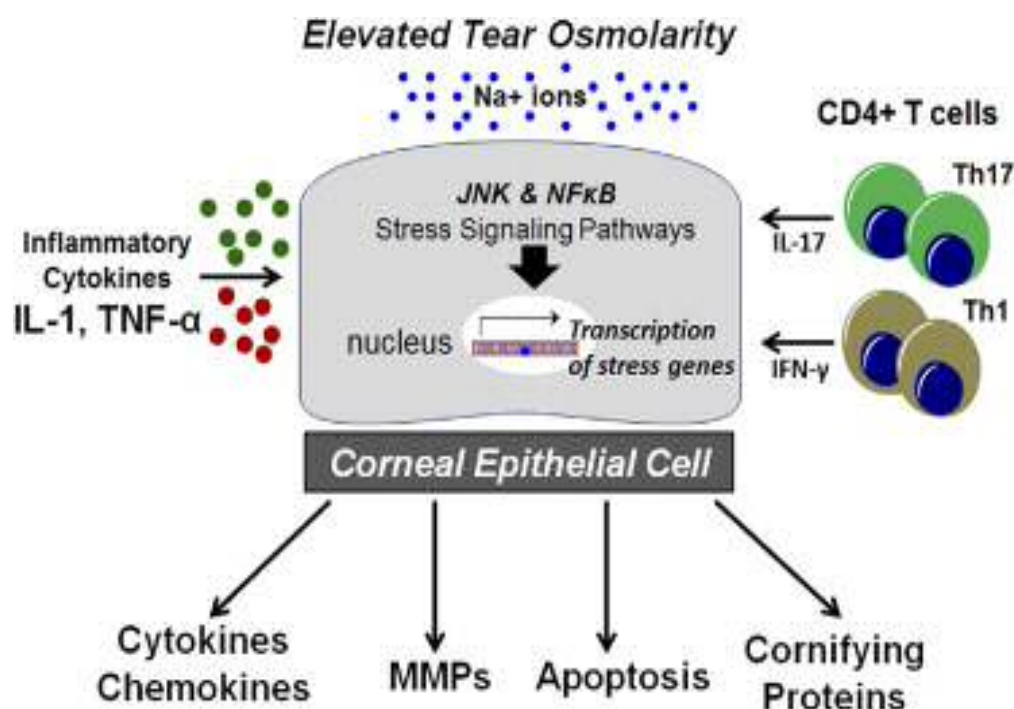


Figure 2-4 Cellular reaction to elevated tear osmolarity.

(Tear dysfunction and the cornea: LXVIII Edward Jackson Memorial Lecture, 2011)

2.5.6 Ocular Surface Staining

As noted, damage to the ocular surface of the eye can occur by hyper-osmolarity of the tear film. A damaged ocular surface can be observed using fluorescein dye to 'stain' the epithelial cells. True staining of the cells does not occur, rather the dye pools in areas of the epithelium where the smooth continuous surface has been interrupted, perhaps by a foreign body track or local cell apoptosis.⁸⁷ The fluorescein is said to pool in the intercellular spaces between the epithelial cells. A negligible fluorescein staining pattern will be observed on an intact ocular surface. GPs, optometrists and ophthalmologists

use fluorescein dye as a diagnostic dye to assess the ocular surface.

The colour intensity gives an indication of the depth of the “defect” at the ocular surface. The general assumption is that any staining seen in a dry eye patient occurs due to hyper-osmolarity and osmotic stress.⁹⁵

A second dye can also be used called Lissamine Green.⁹⁵ Lissamine green is a true dye and is less soluble than fluorescein. It stains damaged cells and mucous fibrils, and is therefore useful for assessing the damage to the goblet cells. By using the attributes of these two diagnostic dyes, the ocular surface can be better assessed.⁹⁶

For a good examination, Yoon et al.,⁹⁷ as well as Korb et al.,⁸⁷ propose a mixture of 1% fluorescein and 1% lissamine green, which shows excellent simultaneous corneal and bulbar conjunctival staining.

2.5.7 Non-Invasive Break-Up Time (NIBUT)

The non-invasive tear break-up time (NIBUT/NITBUT) measures tear film stability without the use of a diagnostic dye.⁸⁸ The idea is to observe the optical distortion that occurs when the tear film thins as a result of evaporation. NIBUT can be measured using several instruments: with a keratometer, corneal topographer, or the purpose-designed Tearscope (Keeler Ltd, Windsor, UK). The time between the last blink and a distortion of the reflex image projected onto the tear film layer is recorded. This measurement is said to show local thinning of the tear film, and is also known as the Tear Thinning Time (TTT).^{98,99} Measurements of NIBUT vs fluorescein TBUT are not comparable, with the NIBUT showing longer times for tear thinning than the fluorescein dye.⁸⁸ The NIBUT is age-dependent, with a decreasing value with increasing age.⁹⁸ All normal values and abnormal values are listed in Table 2-3.

Table 2-2 Diagnostic tests and diagnosis criteria

Diagnostic test	Assessment	Grading system	Diagnosis of dry eye	Reference
Schirmer I	Tear-flow	Measurement of wetting of filter paper strip in mm	<5 mm in 5 mins	Bron et al. (2007) ⁸⁸
BUT	Break-Up Time Tear film stability	Counting the time between last blink and first dark spot in coloured tear film with fluorescein	<10 secs	Bron et al. (2007) ⁸⁸
PRT	Phenol red thread test: tear-flow	Measurement of wetting of cotton thread strip in mm	<10 mm in 15 secs	Bron et al. (2007) ⁸⁸ Chun et al. (2014) ⁸⁹
Fluorescein staining	Damage to corneal epithelium	Different grading systems available to describe the staining of the cornea	Different grading scales available	Sorbara et al. (2015) ⁹⁰
NIBUT	Non-Invasive Break-Up Time: Tear film stability	Counting the time between the last blink and the first distortion of the reflex image at the surface of the tear film	<10 secs	Mengher et al. (1986) ⁹¹
LIPCOF	Assessment of lid-parallel conjunctival folds	LIPCOF is evaluated in the area perpendicular to the temporal and nasal limbus on the bulbar conjunctiva above the lower lid (temporal and nasal LIPCOF)	LIPCOF grade 0-3 (see Figure 1.2)	Hoh et al. (1995) ⁹² Nemeth et al. (2012) ⁹³
Meibography	Assessment of the meibomian glands	Different methods available	Diagnoses of missing glands, terminal duct obstruction or other changes seen at the glands.	Schaumberg et al. (2011) ¹⁸ Den et al. (2006) ⁹⁴
Osmolarity	Osmolarity level in tear film	mOsmol/l	Indication dry eye 316mOsmol/l and up Borderline/intermittent 290 to 316mOsmol/l	

2.5.8 Lid-Parallel Conjunctival Folds (LIPCOF)

Lid-parallel conjunctival folds (LIPCOF) occur at the bulbar conjunctival transition zone at the middle to temporal and nasal thirds of the lower eyelid, as observed with a slit-lamp. These folds are assumed to occur in dry eye patients due to the mechanical force of the eyelids on the conjunctiva that occurs in blinking.⁹³

LIPCOF are considered as having a good positive predictive value when assessed using the LIPCOF scale, and it is seen as a quick and simple non-invasive test.^{92,93,99} Higher LIPCOF degrees correspond significantly with severe subjective symptoms.⁹³

2.5.9 Meibography

Meibomian gland dysfunction (MGD) is the most common cause of evaporative dry eye, causing problems with ocular comfort and visual function.^{18,100} There are several ways to examine the meibomian glands: infrared camera (Figure 2-5), keratographer, and optical coherence tomography (OCT).¹⁰¹ Imaging the meibomian glands using red-free illumination and a slit-lamp camera also allows some observation of the meibomian glands.

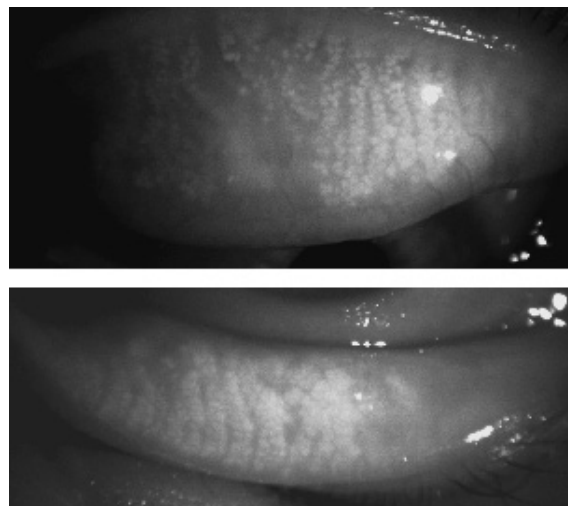


Figure 2-5 In vivo meibography

Top, in vivo meibography using a modified infra-red OCT image; Bottom, infra-red image of the upper lid, showing abnormal meibomian glands. (www.topcon.co.jp)

2.6 Combining Diagnostic Tests

A weak relationship between questionnaire outcome and clinical signs was confirmed by Julio et al. (2012).⁴¹ Their study showed that using either a general global questionnaire or the adjusted Salisbury eye evaluation questionnaire did not predict any clinical signs, although by looking at items separately, the predicted value was better. Using the outcome of looking at the symptoms separately allowed some prediction. For example, having the symptom of 'eyes stuck together in the morning' gave a prediction toward the outcome of the tear ferning pattern, and the symptom dryness gave a prediction for the BUT. The symptoms of 'burning sensation' and 'computer-use for more than 3 hours' were independent variables for tear osmolarity.⁴¹

However, by using a combination of tests, such as NIBUT and nasal LIPCOF, the diagnostic relationship between the subjective complaints and the objective findings can be made stronger.¹⁰²

Pult et al. (2011) showed that combining the OSDI with the NIBUT and nasal LIPCOF, named the Dry Eye Test Combination (DTC), produced a reliable test for differentiating between healthy subjects and mild/moderate dry eye patients.¹⁰²

These approaches suggest that there might still be some value in combining symptoms and signs in diagnosis, but the investigation may need to widen to include more described symptoms, as the patients can reflect their symptoms differently. For example, in the Julio et al. (2012) study, although there was a question about computer-use, these symptoms could be explored more. Apart from the use of computers, other general visually-demanding tasks, such as reading, driving or watching TV, could also be explored.⁴¹ For example, Tong et al. (2010) found that difficulties in visually-demanding tasks, such as driving and reading, were correlated with the position of the Marx's line on the lower eyelid and BUT,⁶¹ making the position of Marx's line a simple screening test for MGD.¹⁰³ MGD is one of the major causes of developing evaporative dry eye.

2.7 Prevalence publications after DEWS 2007

Studies about the prevalence of dry eye problems or dry eye disease (DED) in the Netherlands are not available, but estimates for the world-wide prevalence of DED give a range from as low as 0.1% to as high as 33%.^{26,12} A particular problem when investigating prevalence of DED arises from a lack of consensus about what criteria should be used to define the diagnosis of DED. The use of different questionnaires, survey age populations and survey geographic locations also bias the data, as can the exclusion criteria in the study design by, for example, using specific age groups, or excluding patients with or without symptoms. This makes it even more difficult to accurately describe the prevalence, when taken into account that dry eye signs and symptoms can differ at different disease stages, and be environment specific.

In this thesis, the articles published after the release of the 2007 DEWS Report were used in searching for prevalence numbers in the world, with a special interest in mild/moderate DED symptoms in the age group up to 65 year of age. However, even with the benefit of the DEWS Report, the research reports are not consistent with each other. Searching in the literature was done using the mesh terms: prevalence, dry eye and survey, limited by using only literature published from the year 2006 and onwards.

The studies published after 2007 are more age-dependent than those published earlier. For example, there are studies focused on the prevalence of dry eye symptoms among high school-aged students, as well as subjects 40 years of age and above. In general, both groups have a different lifestyle, which may influence what the patient feels or considers as a problem. Often DED is considered as an age-related disease, but recent studies show that younger persons can also suffer from DED.⁵¹⁻⁵³

Also, when looking at the working population, it is important to consider the change in work activities with more time being spent on computers and inside. In 2003, the Joint Research Centre (JRC) of the European Commission stated that European individuals spend 90% of their time indoors, and that, in offices

and at home, people are more exposed to electronic devices and associated visual stress.

Reviewing the research published after the DEWS 2007 report shows similar outcomes of prevalence of DED in the age group of 40 years of age and up. Only a few studies were included in the DEWS report in a younger age group. Studies in the younger age group, as shown in Table 2-6, may not be representative, as the specific circumstances in which the studies were conducted are likely to influence the outcome. Also, the inclusion of contact lens wearers will influence the outcome of dry eye symptoms, since contact lens-related dry eye symptoms can also be described as discomfort and can be strongly related to contact lens wear modality, contact lens material and solutions used, and hygiene.

2.7.1 Prevalence using the Schaumberg three question questionnaire

The Schaumberg questionnaire is often used in DED prevalence studies, as the questionnaire's three questions are found to provide high specificity for DED diagnosis (Table 2-3).¹⁰⁴ Using these questions, Uchino et al produced a definition of DED that was divided into 3 categories (Table 2-4):

Table 2-3 Schaumberg symptoms-based three question questionnaire.

(1) "Have you ever been diagnosed by a clinician as having dry eye syndrome?"

(2) "How often do your eyes feel dry (not wet enough)?"

"constantly," "often," "sometimes," or "never"

(3) "How often do your eyes feel irritated?"

"constantly," "often," "sometimes," or "never"

Table 2-4 Of the Schaumberg symptoms based questionnaire, three DED categories were formed.

(1) Severe symptoms of DED; both ocular dryness and irritation, either constantly or often

(2) Clinically diagnosed DED as reported by participants

(3) Either clinically diagnosed DED or severe symptoms of DED

The results for prevalence with age are shown in Table 2-5. Recruiting participants in a compromised environment, such as a work office, can bias the prevalence. Also, the participants at a private high school in Japan cannot be said to be in an environment that is comparable with other schools in Japan.

Table 2-5 Prevalence of dry eye using the Schaumberg questionnaire (Schaumberg 2003).

	Age	Selection	N	Severe symptoms Female	Severe symptoms Male	Clinical diagnosed Female	Clinical diagnosed Male
Uchino et al. (2008) ⁵³	22-60	Japanese office workers	3549	48%	26.9%	21.5%	10.1%
Uchino et al. (2008) ¹⁰⁴	15-18	Japanese Private high school students	3455	24.4%	21%	8%	4.3%
Zhang et al. (2012) ¹⁰⁵	10-12	Chinese Senior high school students	1889			11.43%*	12.22%*
Uchino et al. (2011) ⁵¹	40->80	Japanese citizens, Town of Kuomi	2644	21.6	12.5	18.7	11.5
Schaumberg et al. (2009) ¹⁰⁶	50-99	US males ≥50 years, Physicians' Health Studies	3280				4.3%*

*DED was defined as severe symptoms and/or clinically diagnosed; Clinically diagnosed DED was defined as the presence of a DED diagnosis by an ophthalmologist.

2.7.2 Prevalence vs incidence of dry eye with Scheim symptoms-based questionnaire

The Scheim questionnaire consists of 6 questions, all symptoms-based. Briefly, these questions ask about “feeling of dryness”, “grittiness”, “burning sensation”, “redness”, “crusting of lashes”, and “eyelids getting stuck”. The answers are classified into categories: “never”, “rarely” (at least once in three months), “sometimes” (at least once in 2–4 weeks), “often” (at least once a week), and “all the time” (at least once daily).^{67,107} The questionnaires give an inside what the impact is of the felt symptoms even when that cannot be confirmed by diagnostic test (Table 2-6).

Table 2-6 DED prevalence and incidence using the symptom-based Scheim questionnaire.

	Age	N	Subjective Female	Subjective men	Diagnosed female	Diagnosed male
Visio et al. (2009) ¹⁰⁷	40- 96	654	21.8%	12.5%	11.9%	9%
Tongg et al (2009) ¹⁰⁸	40- 80	3280	4.9%	8.2%		
Jie et al. (2008) ¹⁰⁹	40- 84	1957	13.6%	7.4%		

2.8 Diagnosis and treatment

DED is a chronic disease with impacts on visual functioning and daily life, but it is difficult to define in one symptom and, most importantly, no single treatment works for all.^{26,65} In response to this basic problem, a lot of research has been undertaken to investigate the characteristics (Figure 2-6) and treatment of DED and try to reach consensus on a treatment guidelines.^{48,110}

Since DED is principally a symptoms-based condition, it is most often diagnosed by a direct patient assessment,⁷⁷ but this requires a patient/clinician encounter. Without this, it is likely that some sufferers remain undiagnosed.

Even a mild/moderate dry eye can have an impact on the well-being, daily activities, visual functioning or work productivity of a patient.³¹

Self-management, using over-the-counter products for symptom relief, without a diagnosis, could help, although the choice made could be influenced by advice given by pharmacies, as showed in the study of Bilku et al. (2014) in the UK.¹¹¹

The difficulty with dry eye symptoms is the lack of a direct relationship between subjective symptoms and type of DED.^{108,112} In particular, the pain factor is not well understood. Symptoms often vary throughout the day, usually worsening in the evening.¹¹³ Significant complaints can occur even after 2 hours of computer work, and include eye-related pain and tiredness, blurred vision, itchiness, gritty eyes, photophobia, dry eyes, and tearing eyes.⁵⁶ Recommendations for DED management is not regulated by current guidelines in primary healthcare the Netherlands and vary between the General Practitioner (GP) and optometrist.

2.8.1 DEWS diagnostic grid and recommended management

There are a variety of management options for DED, from educating patients on DED, to severe therapeutic intervention, ranging from the use of scleral lenses to systemic anti-inflammatory agents. DEWS 2007 created a diagnosis and treatment grid that looked at DED severity, combined with diagnostic test results and subjective symptoms, to give a guideline for treatment options (Figure 2-6). The idea of DED management is to start with the interventions shown as Level 1, and to then add further interventions to the treatment as the severity level is diagnosed. However, no published investigation was found in primary healthcare about the impact of change in management of DED due to the release of the DEWS report in 2007. Although the National Healthcare System (UK) (NHS) has a recommendation grid for the use of topical treatments from artificial tears to ointments, such specific guidelines do not exist in the Netherlands.

The DEWS Dry Eye Diagnosis Grid* (modified from <i>The Ocular Surface</i> 2007)				
DRY EYE SEVERITY LEVEL	1	2	3	4
Discomfort, severity, and frequency	Mild/episodic/ environmental stress	Moderate/episodic or chronic/environmental stress or no stress	Severe/frequent or constant without stress	Severe and disabling, constant
Visual symptoms	None or episodic mild fatigue	Annoying and/or activity limiting episodic	Annoying, chronic and/or constant limiting activity	Constant and/or possibly disabling
Lid/meibomian glands	MGD variably present	MGD variably present	Frequent	Trichiasis, keratinization, symblepharon
TFBUT (sec)	Variable	≤ 10	≤ 5	Immediate
Corneal Staining (NEI Scale 0-15)	None to mild	Variable	Central	Severe punctuate erosions
Conjunctival Staining (NEI Scale 0-18)	None to mild	Variable	Moderate to marked	Marked
Schirmer test (no anesthesia) (mm/5 min)	Variable	≤ 10	≤ 5	≤ 2
Recommended management	Patient education, diet modification and lid therapy, artificial tear/gel supplements, environmental control	Add anti-inflammatories, tetracyclines, punctal plugs, moisture chamber spectacles	Add autologous serum, bandage or large-diameter rigid contact lenses, permanent punctual occlusion	Add systemic anti- inflammatory agents, surgical intervention

* The order of the tests represents a common dry eye exam sequence. Recommended management is listed below each grade.

Figure 2-6 Dry eye severity scheme, modified from the DEWS Report 2007.

2.9 Prevalence of DED in the Netherlands

In the Netherlands, whilst no data is currently available about the prevalence of DED, it is possible to use the data detailing the prescribed medication for dry eye as a guide. Artificial tears prescribed by GPs and eye specialists are registered in the Netherlands by the information system (GIP) of the Health Care Insurance Board. It contains information of a representative sample of the more than 17 million people of the Dutch population (2017). The register includes prescription-related data on drugs that are prescribed by GPs and specialists, and dispensed by pharmacists, dispensing GPs and other outlets, as well as those reimbursed under the Health Care Insurance Act. The data is based on 1 prescription per year per patient. The information in this database may not be representative for all DED patients in the Netherlands.

Based on this database, artificial tears and other dry eye products were prescribed to 487,500 patients (male and female,) in 2009, and increased to 542,210 in 2011 and 586,930 in 2015. The number of users of specific group artificial tears was 588,348 in (2015), while the number of users of cyclosporine was only 406. The age group of users of the users of artificial tears is shown in Figure 2-7.

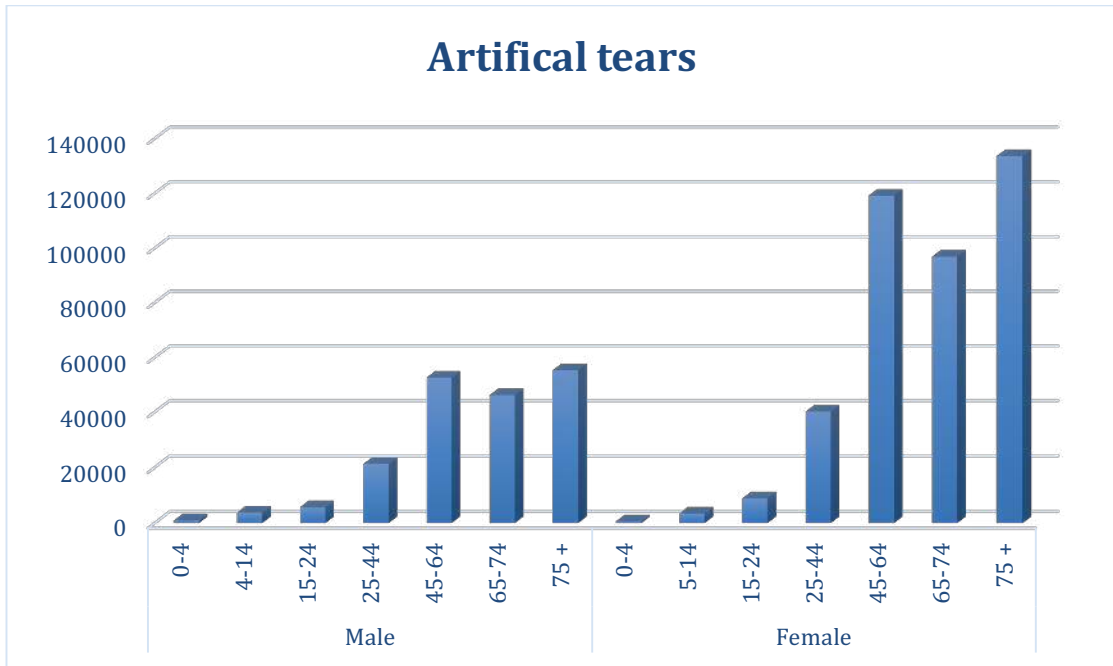


Figure 2-7 Users of prescribed artificial tears per age group (2015) (Gipdatabank.nl, 2015).

The number of users of artificial tears and related products was ranked at 21st in 2015. These numbers did not include the non-prescribed artificial tears advised or bought by the patient as a self-management. Optometrists in the Netherlands can prescribe, and advise on, over-the-counter artificial tears available on the Dutch market, and patients can self-manage using over-the-counter artificial tears sold by pharmacists, opticians and drugstores.

The consultation time for GPs, optometrists and ophthalmologists needed for DED patients is not counted in this literature review, so the specific annual cost for DED in the Netherlands is not available. It is expected that the aging population will have an impact on healthcare costs in the future, and so, to keep the healthcare system affordable, the effective and cost-efficient management of DED is important too.

However, one study investigated the annual cost of DED in several other European countries.¹¹⁴ The conclusion was that DED was not imposing a direct burden on the cost of healthcare. However, when DED is seen as a chronic condition, with the high prevalence of DED, the number of repeat visits to the hospital, and the number of individuals who self-treat, or were seen by an

optometrist or a GP, the direct cost of DED could be significant.

Moreover, Patel et al. (2011) showed a negative impact from moderate-severe DED on work productivity, and these costs need to be incorporated, along with the health costs.⁷¹

A review by McDonald et al. (2016)¹¹⁵ confirmed that there is no published literature that has identified the productivity loss and related indirect costs from DED in Europe. They found only 12 articles that could fulfil the criteria for research on the economic and health-related QoL with DED, showing a need for more research on this topic. In general, the review showed higher direct and indirect costs for DED, from the cost of health care, the loss of work productivity, depression, and the cost of over the counter self-treatment.¹¹⁵

The personal and economic consequences of having DED are thought to be under-estimated, and are receiving increasing attention as a result.^{30,115} The type and variety of personal impact on the QoL, such as decreased work productivity, illness perception, anxiety, and even depression, gives DED an influence on not only the physical aspects of daily life, but also on the emotional and social aspects.¹¹⁶ As a result of decreased productivity from DED in the workplace, it is estimated that the economic burden exceeds the direct cost of care.^{31,74,115}

2.10 Healthcare in the Netherlands

Health insurance in the Netherlands is called the *Zorgverzekeringswet* (ZVW), and it is provided for every registered resident in the Netherlands. The government determines coverage of the basic package of health insurance, and health insurance companies have an obligation to accept everyone for the basic package, irrespective of gender, age and health. The content of the basic package is subject to on-going review and change. Supplementary packages can cover physiotherapy, spectacles, dental help for persons of 18 years and

older, and alternative medicine, such as homeopathy and acupuncture.² The basic or supplementary package does not include optometric care, although changes are expected to include payment for optometric consultation in the near future.

The Netherlands spent €57.5 billion on healthcare in 2003, an equivalent to about 12% of the Gross National Product (GNP), or €3,550 per capita.³

2.10.1 General Practitioner

The general medical practitioner (GP) has a dominant role in the ZVW as the gatekeeper for referral to other medical services. Without a referral, the health insurance company will not reimburse the costs.

The latest data (2011) gives an estimate of around 8,000 self-employed GPs in the Netherlands (NIVEL, 2011). GPs administer primary healthcare 24 hours a day, 7 days a week, with after-work hours and weekends coverage provided by GPs located at central posts called Huisartsen Praktijk (HAP). The academic requirements for a GP consist of a four-year master's degree in medicine, followed by GP specialist training, which takes 3 years full-time and includes an internship.

2.10.2 Optometrists

European countries differ in the way primary eye care is provided. Optometrists in the UK are established as the primary practitioners in eye care. In other European countries, eye care professionals, optometrists, contact lens specialists and even opticians, have a more restricted role in the investigation of eye problems.

² ("Health Care Reform and Long-Term Care in the Netherlands," 2013b; "Kosten van ziekten in Nederland 2003. Zorg voor euro's RIVM Report No: 270751010. Bilthoven," 2006).

³ ("Health Care Reform and Long-Term Care in the Netherlands," 2013b; "Kosten van ziekten in Nederland 2003. Zorg voor euro's RIVM Report No: 270751010. Bilthoven," 2006).

The World Council of Optometry (WCO) produced a report on the competency and scope of practice of optometrists' worldwide in 2011. The list contains 4 different levels, and optometrists in the Netherlands are qualified at Level 3:

Level 1 Optical Technology Services:

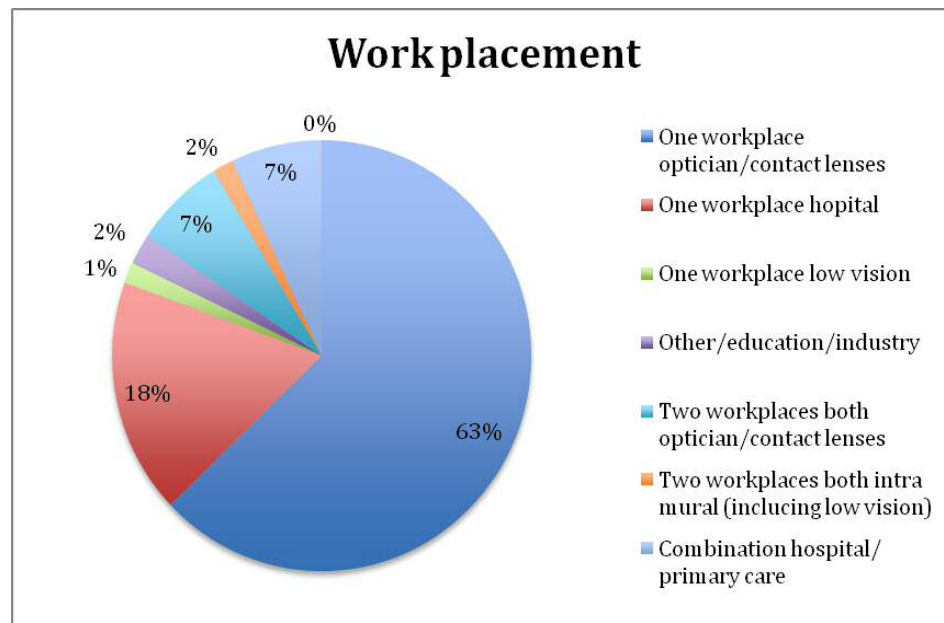


Figure 2-8 Work placements of optometrist member of the OVN 2012

2.10.3 Occupational Healthcare Physician (OHP)

Over the previous two decades, occupational healthcare in the Netherlands has been focused on illness-related absences and work disability. More recently, the development and implementation of practice guidelines for occupational healthcare physicians (OHP) has improved care, making it more evidence-based and more oriented toward preventive actions to improve participation at work. Occupational healthcare is aimed at:

- Safe work for employees
- Prevention of work-related diseases
- Participation of employees with and without limitations
- Improvement of functioning at work

The broad orientation of the OHP requires a multi-disciplinary approach involving collaboration with other OHP professionals, GPs, and paramedical specialists.

Around 2,000 OHPs are working in the Netherlands. They aim to be integrated into the early stages of the treatment process for employees with (chronic) disease to ensure continuation in work. This underscores a need for better collaboration between occupational and general healthcare.¹¹⁷

2.11 Substitutional potential of the optometrist in primary healthcare

van Hassel et al. (2013), using data from an empirical research study by the Netherlands institute for Health Services Research (NIVEL) (2012), considered the potential substitutionary role of the optometrist as a primary healthcare professional. It was estimated that 207,000 patients/year, who would normally consult a GP, could be seen by the optometrist, and up to 21,000 patients/year would be prevented from having to go to the ophthalmologist.¹¹⁸ This estimation was based on a potential number of eye diseases. They estimated that GPs were seeing over 40,000 patients/year with tear film associated symptoms, while the optometrists were seeing over 7000 patients/year.¹¹⁹

2.11.1 Investigation of the attitude in healthcare towards dry eye disease

In the research literature published since 2005, few studies were conducted in primary healthcare on the attitude of healthcare professionals towards the diagnosis and management of DED, with most undertaken in secondary healthcare by ophthalmologists.^{120,121} Of those published, the latest research studies have been conducted in Asia, but there are large differences in education and scope of practice in Asia, and even between the United States, United Kingdom and the Netherlands, optometrists do not have the same scope of practise. The approach taken towards DED by GPs is not reported on at all.

Differences in the management of DED between ophthalmologists and optometrists is also not well investigated, nor is the difference in management between the GP and optometrist. One study by Turner et al. (2005) investigated the attitude of a small number of ophthalmologists towards dry eye.¹²¹ They found that ophthalmologists have a negative attitude and low satisfaction with the diagnostic tests, especially the poor correlation between subjective reports and objective findings.

2.12 Healthcare pathways

“We need a comprehensive, integrated approach to service delivery. We need to fight fragmentation.”

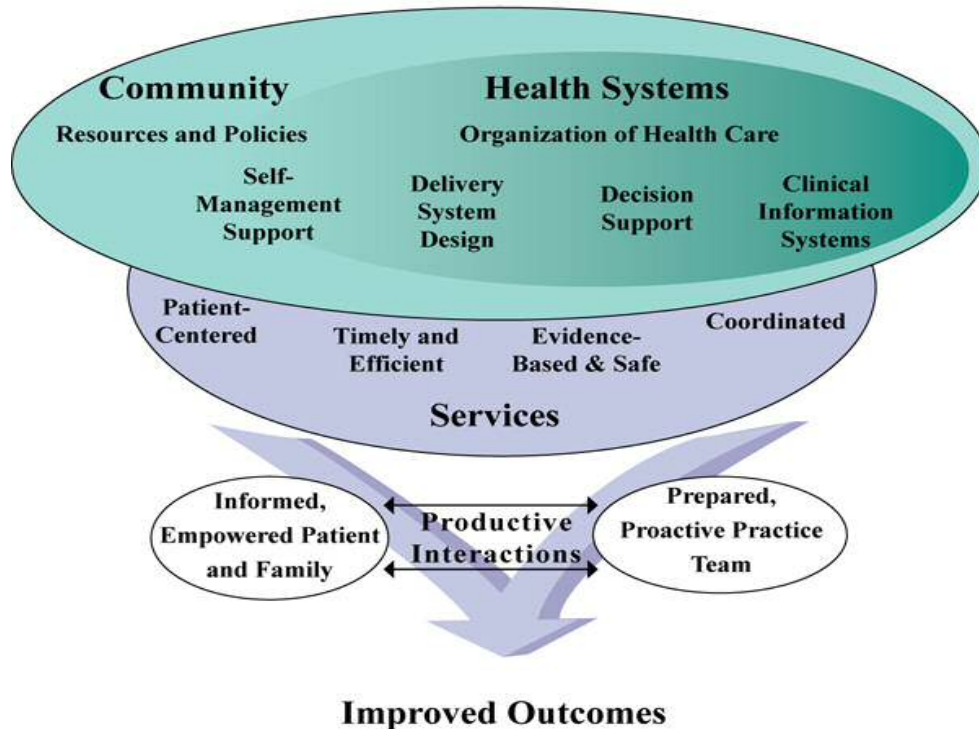
WHO Director-General, 2007

To strengthen a health delivery system, health service care pathways are designed and implemented. In the literature, different names are used for care pathways, such as clinical pathway or critical pathways or integrated care pathways, or even care maps. They can be focused on one patient group or more broadly, and can be hospital-based, in primary healthcare, or cross over between these two levels of health service.¹²² A care pathway only succeeds when the satisfaction of the patient with the delivered care increases.¹²²

In 2011, the Health Assembly of the WHO urged Member States *“to continue, as appropriate, to invest in and strengthen health-delivery systems, in particular in primary healthcare and services”*, with the purpose of ensuring fair access to healthcare, and to develop an appropriate balance between health promotion, disease prevention, rehabilitation and healthcare provision.¹²³

Care pathway or integrated healthcare services can also be used to organise healthcare, and for that a chronic care model is used.^{124,125} The chronic care model (Figure 2-9) is complementary to primary care (patient-centered care) with the focus on person-focused care, although the chronic care model is typically diseased-oriented, with a primary focus on care over time.

The Care Model



Developed by The MaColl Institute

Figure 2-9 The Chronic Care Model, developed by the MaColl Institute.

It is noted that care pathways are most effective in low complexity care. When there is a need for a treatment guideline, professionals from different areas of expertise are brought together to develop an 'integrated care pathway'.¹²⁶ In this way, the development of a care pathway can also be used as a communication tool between professionals, and to promote teamwork and inter-professional cooperation.^{122,125}

The difference between Patient-Centred Care (PCC) and Person-Focused Care (PFC) is shown in Table 2-7.

The definition of integrated health services given by the WHO is “*health services that are managed and delivered so that people receive a continuum of health promotion, disease prevention, diagnosis, treatment, disease-management, rehabilitation and palliative care services, coordinated across the different levels and sites of care within and beyond the health sector, and according to their needs throughout the life course*”.¹²⁷

Table 2-7 Differences between patient-centred care and person-focused care.

Patient-centred care	Person-focused care
Generally refers to interactions in visits	Refers to inter-relationships over time
May be episode-oriented	Considers episodes as part of life-course experiences with health
Generally centers around the management of diseases	Views diseases as inter-related phenomena
Generally views co-morbidity as number of chronic diseases	Often considers morbidity as combinations of types of illnesses (multi-morbidity)
Generally views body systems as distinct	Views body systems as inter-related
Uses coding systems that reflect professionally-defined conditions	Uses coding systems that also allow for specification of a person's health concerns
Is concerned primarily with the evolution of a patient's diseases	Is concerned with the evolution of a person's experienced health problems, as well as with their diseases

Adopted from: Starfield, B. (2011). Is patient-centered care the same as person-focused care? *The Permanente Journal*, 15(2), 63–69.

2.13 Integrated People-Centred Health Services

In the Framework on Integrated People-Centred Health Services, the WHO¹²⁷ put forward five inter-dependent strategies for developing a framework:

- (1) empowering and engaging people and communities;
- (2) strengthening governance and accountability;
- (3) reorienting the model of care;
- (4) coordinating services within and across sectors;
- (5) creating an enabling environment.

These five strategies are seen as cumulative and a lack in any one area will undermine progress in the other areas.¹²⁷

Integrated health service delivery is defined as “*the organisation and management of health services so that people get the care they need, when they need it, in ways that are user-friendly, achieve the desired results, and provide value for money.*”¹²⁸

People-centred care is defined as “an approach to care that consciously adopts individuals’, carers’, families’ and communities’ perspectives as participants in, and beneficiaries of, trusted health systems that are organised around the comprehensive needs of people rather than individual diseases, and respects social preferences. People-centred care also requires that patients have the education and support they need to make decisions and participate in their own care, and that carers are able to attain maximal function within a supportive working environment. People-centred care is broader than patient and person-centred care, encompassing not only clinical encounters, but also including attention to the health of people in their communities and their crucial role in shaping health policy and health services.”¹²⁷

2.14 Chronic Care Model

One of the most-used models for an integrated health care services or healthcare pathway is the chronic care model (Figure 2-9). The Dutch government is looking at the chronic care model to implement it with chronic diseases, such as Diabetes, and Chronic Obstructive Pulmonary Disease (COPD), after they concluded that the current health system is not complementary towards the needs of the fast growing population with chronic disease. ^{124,125}

Ham et al. (2010)¹²⁹ suggested the ten characteristics of a good performing chronic care model:

1. Universal healthcare coverage
2. Care free of the point of delivery
3. Focus on prevention of ill-health
4. Priority is given to supporting self-management
5. Priority is given to primary care
6. Population management is emphasised
7. Care should be integrated
8. The potential benefits of IT should be exploited
9. Care is co-ordinated effectively
10. Characteristics 1-9) should be linked as part of a coherent strategy

This framework could be used to cause a change in the health system in the Netherlands for DED care. For implementation of such a care system, there would need to be willingness, effective communication and collaboration between the care professionals.

2.14.1 Self-management

In the chronic care model, priority is given to self-management, meaning that education towards the patient is in collaboration with their healthcare professionals and their family. Collaboration and cooperation in primary healthcare is needed to fulfill the role of the professional in self-management in the chronic care model for DED.

2.15 Inter-professional cooperation

Inter-professional cooperation in eye care should involve opticians, optometrists, ophthalmologists, GPs, orthoptists, low vision specialists, OHPs, other healthcare workers, and patient organisations.

However, there are few studies in the literature concerning inter-professional cooperation with optometrists. Farlow et al. (2015)¹³⁰ reported on an optometrist who was involved in an inter-professional clinic which provided primary care to patients with physical disabilities, as part of a community-based falls prevention program.¹³⁰ Long et al. (2014) undertook an inter-professional discussion regarding improvements in visual comfort and productivity at work, and found that promoting good communication between optometrists and ergonomists was the starting point for inter-professional cooperation.¹³¹ Jamous et al. (2014) looked at the referral pathways from the optometrist to other healthcare professionals. They found that referrals to GPs and low vision services were for enhanced patient care, while referrals to ophthalmologists were more diagnostic-based and looked at patient functioning.¹³² In the Netherlands, a comparative study was conducted in 2007 to address expertise as “the foundation of professional boundaries and domains” of opticians, optometrists, GPs and ophthalmologists.

Table 2-8 Competencies for inter-professionality

Inter-professional Education Collaborative (IPEC) 2016

Competency 1
Work with individuals of other professions to maintain a climate of mutual respect and shared values. (Values/Ethics for Inter-Professional Practice)
Competency 2
Use the knowledge of one's own role and those of other professions to appropriately assess and address the healthcare needs of patients, and to promote and advance the health of populations. (Roles/Responsibilities)
Competency 3
Communicate with patients, families, communities, and professionals in health and other fields in a responsive and responsible manner that supports a team approach to the promotion and maintenance of health and the prevention and treatment of disease. (Inter-professional Communication)
Competency 4
Apply relationship-building values and the principles of team dynamics to perform effectively in different team roles to plan, deliver, and evaluate patient/population-centred care and population health programs and policies that are safe, timely, efficient, effective, and equitable. (Teams and Teamwork)

For inter-professional cooperation, recognition of the 'other' profession was very important. In the study, the "specialised" optometrist had less problem with inter-professional recognition by other professionals than other optometrists.¹³³

Inter-Professional Cooperation (IPC) starts with Inter-Professional Education (IPE). A list of expected competencies needed for success in a chronic care model were described by the Inter-professional Education Collaborative (IPEC) in 2016 (Table 2-8).¹³⁴

2.16 DED pathway in the Netherlands

There is no treatment pathway for DED in the Netherlands, either between GPs and optometrists, or between ophthalmologists and optometrists, at either the national or regional level.

In the Netherlands, GPs diagnose DED by considering the subjective complaints presented by the patient, whereas the optometrist diagnoses on both subjective symptoms and objective signs, but by working together in a good healthcare model, the two professions could strengthen eye care in primary care. Primary care is, at its heart, person-focused care. It is said that diagnosis alone is not responsible for better care, rather, care is better when the problem is recognised as being both patient-centered and person-focused.¹³⁵ Extra skills are needed by the professionals, when sharing decision-making in disease management, not only to educate the patient, but also to promote self-management by the patient.

The ophthalmologist, as do all hospital-based professionals, works primarily in diagnosis and treatment, and there are some studies that evaluate specialist care models, for stroke, heart failure, COPD and diabetes care.^{136,137}

2.17 The Chronic Care model for improving outcomes

Although DED is defined as a chronic disease, there is no evidence that GPs and optometrists in the Netherlands see it as a chronic disease. When DED patients are diagnosed in primary healthcare and they are referred to the secondary healthcare, but the lack of a patient-centred care pathway could cause a recurrence of patient visits to the care professionals for help.

Patients with work-related DED would benefit from a chronic care model that includes OHPs, especially when looking at patient-centered care, prevention and functionality, which are the core business for OHPs. OHPs want to know if the patient with DED has received the proper treatment for their symptoms, since, in the management of a chronic disease, such as DED, when the treatment is as good as it can be, other aggravating factors have to be

acknowledged and the OHP, with the patient, can investigate other ways to improve the environment for the patient to function better.

2.18 The International Classification of Functioning, Disability and Health and Health

The International Classification of Function, Disability and Health (ICF), developed by the World Health Organisation (WHO) in 2001, defines human functioning by considering each health condition, and the various factors that can influence the activities and participation of someone with the condition. It gives an overview by looking at body functions and structures, as well as personal and environmental factors. The model (Figure 2-10) is used to look at the whole context of rehabilitation.

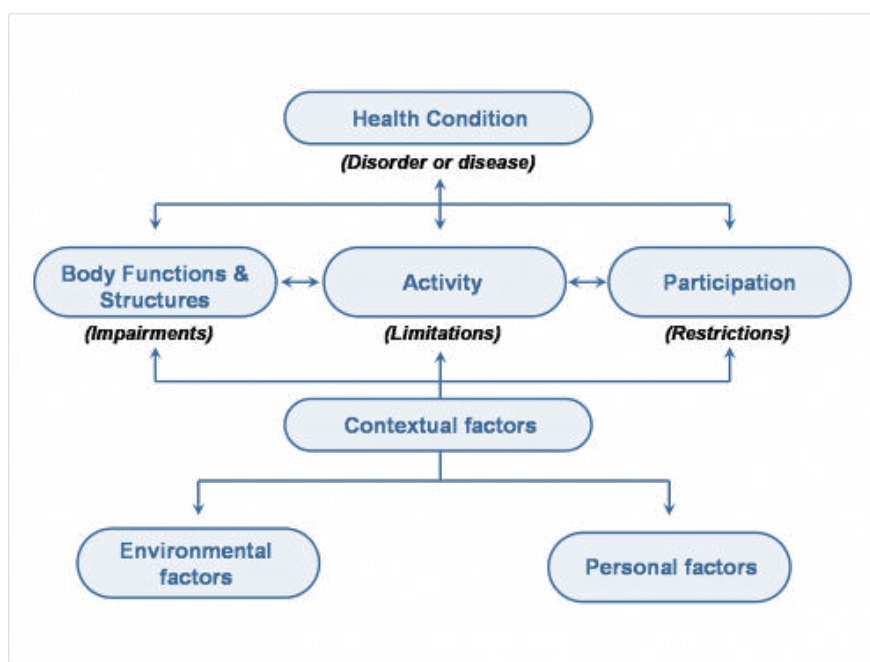


Figure 2-10 ICF classification by the World Health Organisation (WHO) 2001.

Looking at DED, whether diagnosed or not, OHPs, GPs and optometrists may not be trained and prepared to manage rehabilitation of individuals with DED symptoms in this context.

2.18.1 Health condition

To translate a health condition to a coding system, the International Classification of Primary Care (ICPC) coding system is used by GPs, but not by

optometrists (Figure 2.11). The ICPC uses a process code to classify by symptoms/complaints and diagnosis, and is mapped to the ICD. It was developed by the World Organisation of Family Doctors (WONCA) International Classification Committee (WICC). The ICPC-2 was last revised in 2015.

ICPC-2 – English International Classification of Primary Care – 2 nd Edition Wonca International Classification Committee (WICC)	Blood, Blood Forming Organs and Immune Mechanism B	Eye	F	Musculoskeletal	L
	B02 Lymph gland(s) enlarged/painful	F01 Eye pain		L01 Neck symptom/complaint	
	B04 Blood symptom/complaint	F02 Red eye		L02 Back symptom/complaint	
	B25 Fear of aids/HIV	F03 Eye discharge		L03 Low back symptom/complaint	
	B26 Fear cancer blood/lymph	F04 Visual floaters/spots		L04 Chest symptom/complaint	
	B27 Fear blood/lymph disease other	F05 Visual disturbance other		L05 Flank/axilla symptom/complaint	
	B28 Limited function/disability	F13 Eye sensation abnormal		L07 Jaw symptom/complaint	
	B29 Symp/compit lymph/immune other	F14 Eye movements abnormal		L08 Shoulder symptom/complaint	
	B70 Lymphadenitis acute	F15 Eye appearance abnormal		L09 Arm symptom/complaint	
	B71 Lymphadenitis non-specific	F16 Eyelid symptom/complaint		L10 Elbow symptom/complaint	
	B72 Hodgkin's disease/lymphoma	F17 Glasses symptom/complaint		L11 Wrist symptom/complaint	
	B73 Leukaemia	F18 Contact lens symptom/complaint		L12 Hand/finger symptom/complaint	
	B74 Malignant neoplasm blood other	F27 Fear of eye disease		L13 Hip symptom/complaint	
	B75 Benign/unspecified neoplasm blood	F28 Limited function/disability (f)		L14 Leg/hiqh symptom/complaint	
	B76 Ruptured spleen traumatic	F29 Eye symptom/complaint other		L15 Knee symptom/complaint	
	B77 Injury blood/lymph/spleen other	F70 Conjunctivitis infectious		L16 Ankle symptom/complaint	
	B78 Hereditary haemolytic anaemia	F71 Conjunctivitis allergic		L17 Foot/toe symptom/complaint	
	B79 Congen anom. blood/lymph other	F72 Blepharitis/stye/chalazion		L18 Muscle pain	
	B80 Iron deficiency anaemia	F73 Eye infection/inflammation other		L19 Muscle symptom/complaint NOS	
	B81 Anaemia, Vitamin B12/folate def.	F74 Neoplasm of eye/adnexa		L20 Joint symptom/complaint NOS	
	B82 Anaemia other/unspecified	F75 Contusion/haemorrhage eye		L26 Fear of cancer musculoskeletal	
	B83 Purpura/coagulation defect	F76 Foreign body in eye		L27 Fear musculoskeletal disease other	
	B84 Unexplained abnormal white cells	F79 Injury eye other		L28 Limited function/disability (f)	
	B87 Splenomegaly	F80 Blocked lacrimal duct of infant		L29 Symp/compit. Musculoskeletal other	
	B90 HIV-infection/aids	F81 Congenital anomaly eye other		L70 Infections musculoskeletal system	
	B99 Blood/lymph/spleen disease other	F82 Detached retina		L71 Malignant neoplasm musculoskeletal	
		F83 Retinopathy		L72 Fracture radius/ulna	
	PROCESS CODES	F84 Macular degeneration		L73 Fracture: tibia/fibula	
		F85 Corneal ulcer		L74 Fracture: hand/foot bone	
		F86 Trachoma		L75 Fracture: femur	
		F91 Refractive error		L76 Fracture: other	
		F92 Cataract		L77 Sprain/strain of ankle	
	SYMPTOMS/COMPLAINTS	F93 Glaucoma		L78 Sprain/strain of knee	
		F94 Blindness		L79 Sprain/strain of joint NOS	
		F95 Strabismus		L80 Dislocation/subluxation	
		F99 Eye/adnexa disease, other		L81 Injury musculoskeletal NOS	
	INFECTIONS	Ear	H	L82 Congenital anomaly musculoskeletal	
		H01 Ear pain/earache		L83 Neck syndrome	
	NEOPLASMS	H02 Hearing complaint		L84 Back syndrome w/o radiating pain	
		H03 Tinnitus, ringing/buzzing ear		L85 Acquired deformity of spine	
	INJURIES	H04 Ear discharge		L86 Back syndrome with radiating pain	
		H05 Bleeding ear		L87 Bursitis/tendinitis/synovitis NOS	
	CONGENITAL ANOMALIES	H13 Plugged feeling ear		L88 Rheumatoid/seropositive arthritis	
		H15 Concern with appearance of ears		L89 Osteoarthritis of hip	
	OTHER DIAGNOSES	H27 Fear of ear disease		L90 Osteoarthritis of knee	
		H28 Limited function/disability ear		L91 Osteoarthritis other	
	Digestive D	H29 Ear symptom/complaint other		L92 Shoulder syndrome	
	D01 Abdominal pain/cramps general	H70 Otitis externa		L93 Tennis elbow	
	D02 Abdominal pain epigastric	H71 Acute otitis media/myringitis		L94 Osteochondrosis	
	D03 Heartburn	H72 Serous otitis media		L95 Osteoporosis	
	D04 Rectal/anal pain	H73 Eustachian salpingitis		L96 Acute internal damage knee	
	D05 Perianal itching	H74 Chronic otitis media		L97 Neoplasm benign/unspec musculo.	
	D06 Abdominal pain localized other	H75 Neoplasm of ear		L98 Acquired deformity of limb	
	D07 Dyspepsia/indigestion	H76 Foreign body in ear		L99 Musculoskeletal disease, other	
	D08 Flatulence/gas/belching	H77 Perforation ear drum		Neurological N	
	D09 Nausea	H78 Superficial injury of ear		N01 Headache	
	D10 Vomiting	H79 Ear injury other		N03 Pain face	
	D11 Diarrhoea	H80 Congenital anomaly of ear		N04 Restless legs	
	D12 Constipation	H81 Excessive ear wax		N05 Tingling fingers/feet/toes	
	General and Unspecified A				
A01 Pain general/multiple sites					

Figure 2-11 The ICPC-2 as designed by the World Organisation of Family Doctors (WONCA) International Classification Committee (WICC).

Ophthalmologists in the Netherlands use the International Classification of Disease (ICD) system. This is an accepted protocol for describing disease and other, related, health problems. Secondary healthcare in the Netherlands uses the ICD-9 classification. ICD-10 is not yet adopted in the Dutch system.

There are some differences in the ICPC from the ICD which makes it difficult to match the incidence and prevalence of DED symptoms reported by GPs under the ICPC F99 code (eye/adnexa disease and others). Similarly, ICPC F13

‘abnormal eye sensation’ could apply to all dry eye-related symptoms when using the Dutch translation.

Nevertheless, with these codes NIVEL publishes the incidence and prevalence of health problems using the NIVEL Primary Care Database. This database uses data from a range of healthcare providers (GPs, pharmacists, physiotherapists, dieticians, primary care psychologists, remedial teachers).

The latest data published shows an incidence of 6.7 and a prevalence of 11.8 for F99, which contains several eye and adnexa diseases, including tear film insufficiency, with an incidence of 14.8 and prevalence of 12.4. Unfortunately, the ICPC codes changed during the last few years, making it difficult to identify changes.

Table 2-9 Incidence and Prevalence eye and adnexa disease NIVEL 2015 (21-06-2017)

F99 – Eye and adnexa diseases (others)	incidence 6.7; prevalence 11.8
F99.01 Xanthelasmata palpebrae	
F99.02 Blepharochalasis	
F99.03 Entropion/ectropion	
F99.04 Pterygium	
F99.05 Scleritis/epi scleritis	
F99.06 Tear film insufficiency	
F13 Eye sensation abnormal	incidence 14.8; prevalence 12.4

2.19 Summary

2.19.1 DED is a very common illness

In the Netherlands, there was a 35% increase in the prescription of artificial tears by physicians during the years 2009-2013. However, the number of prescriptions for artificial tears cannot be a simple description of the scale of problems from symptoms experienced by DED patients, as it is known that DED

has an impact on visual functioning and QoL.⁵⁴ The severity of DED is probably under-diagnosed and the chronic nature of the disease is of importance for its impact on healthcare professionals and healthcare pathways.

2.19.2 Patient must be central

To diagnose DED, it is important to combine subjective and objective findings. A typical baseline knowledge of ocular pathology and management (GP or optometrist) would not be sufficient, as a large part of the symptoms from work-related DED are complex, and made more so by the impact of the work-related indoor environment.^{38,39} Also, the use of electronic devices at a younger age and their use by an aging work population needs to be addressed in management decisions. For the work-related DED patient, a more inter-professional approach is probably needed to address all the management options available.

2.19.3 Healthcare pathways

The impact of work-related DED in the Netherlands is not clear, there is no care pathway in the Netherlands for treatment, and no inter-professional collaboration for managing DED. In primary healthcare, the optometrist and GP are the gatekeepers to the secondary eye care, while the OHP is involved when there are work-related symptoms affecting work productivity or activity during the day, causing long-term sick leave. There is a need for a new healthcare pathway that involves the optometrist in the diagnosis of DED in primary healthcare. To enhance patient skills in self-management, cooperation between health professionals is needed. The healthcare professional also needs the skills to educate the patient and family on the steps that can be beneficial to better quality of life.

2.20 This PhD has two principal aims:

- 1) To discover more about the impact of work-place related dry eye for those working in office buildings with highly demanding visual tasks.
- 2) To explore how a possible work-related DED pathway would fit into primary healthcare in the Netherlands, to enhance patient care.

In study 1 (Chapter 3)

The aim of this study was to investigate the type and prevalence of dry eye-related symptoms arising from the use of electronic devices in highly visually-demanding reading/computer work, in a modern, open-plan flexible-working office, without local control of air-conditioning. This study investigated DED symptoms at work and at home, the influence of the environment and the influence on DED symptoms during the working day. Attention was made to the role of the caregivers (GPs, OHPs and optometrists), in diagnosis and management.

In study 2 (Chapter 4)

This explorative study was conducted to test the hypothesis that environmental factors are reflected in the severity of the DED symptoms and in worker dissatisfaction of the workplace and workstation. The investigation was done in an office environment with a low humidity with flexible-work practices. The offices workers were using electronic devices, such as computers, laptop or tablet, during the day.

In study 3 (Chapter 5)

This explorative study was conducted to test the hypothesis that the environmental factors are can affect tear film characteristics, the eye and adnexa, and subjective complaints of office workers.

In study 4 (Chapter 6)

The primary aim was to investigate current knowledge, examination tests and management methods for DED in primary care by GPs and optometrists. The secondary aim was to determine the agreement between optometrists and between GPs in relation to subjective dry eye symptoms, the causes of developing dry eye, the use of investigative techniques, and the treatment options used.

In study 5 (Chapter 7)

The primary aim of this investigation, by using the Delphi method, was to seek consensus between professionals on aspects of DED care to investigate a

possible theoretic care model for DED patients in primary healthcare. Three groups of professionals were invited to join the investigation: optometrists, GPs and OHPs. Over three rounds of questions, the knowledge, possible needs, attitude towards healthcare models, responsibility and ownership of the management of DED were investigated.

General discussion (Chapter 8)

This chapter draws together the main findings from the studies described in this thesis, followed by general recommendations and future research.

An article based on this research is accepted

Van Tilborg MMA, Kort HSM, Murphy PJ. Dry Eye Disease and Ageing. Gerontechnology

3 Impact of dry eye symptoms and daily activities in a modern office

3.1 Study 1: Introduction

Workers in modern offices with flexible working (flex) workspaces are vulnerable to personal (e.g. thermal discomfort) and ocular discomfort (e.g. dry eye) due to variations in environmental conditions and poor air quality.¹³⁸ The ideology of flexible workspaces is that the employee can choose their workspace location and arrangement for the specific task. The buildings are built with the same concept: most workspaces are "unassigned" or touchdown spaces. There are areas for specific activities accessible to all employees, such as (formal) meeting spaces, project rooms, and some individual workspaces. For modern office buildings, poor air quality has a strong relationship to dry eye symptoms, tiredness of the eyes and irritation.⁴⁴ These complaints arise from two main factors: increasing use of computers and changes to building air-conditioning control.

Several researchers have investigated the impact of blink frequency during specific tasks, such as reading or computer work, and showed that the position of the monitor influences blink frequency.²⁰ Moreover, blink frequency decreases while reading from a computer screen by 2-3 times. This leads to less protection for the cornea from environmental conditions, especially when the computer monitor is positioned directly ahead, since tear film break-up time (BUT) is reduced during reading from a computer screen, indicating an unstable tear film.^{3,22} The reduction in blink-rate and incomplete blinking will lead to reduced tear stability, which is known to be increased by low humidity and higher airflow in the indoor environment.^{3,38}

Increased evaporation is a possible cause for discomfort of the eyes, and especially for dry eyes.^{4,26} Increased osmolarity levels produced by the increased evaporation from the tear film stimulates an inflammatory process leading to increased dry eye symptoms, such as irritation, pain and corneal epithelial damage.^{19,10}

The environment can cause symptoms that can be divided into mucous membrane symptoms (related to the eyes, nose, and throat) and dry skin, and general symptoms (headaches and lethargy).⁴² When the symptoms are related to the building environment and disappear after leaving the building the term Sick Building Syndrome (SBS) will be used. Females are vulnerable for experienced symptoms of SBS.^{42,43,139,140} Low relative humidity, high room air temperatures, high air velocity, high levels of air pollution and a task-related work environment are known factors to increase dry eye symptoms.^{3,32} However, it is not known at what level these factors cause an increased risk for developing dry eye symptoms.³

Eye problems associated with the office environment can be divided into binocular vision-related eye problems, such as eye-strain, double vision or tired eyes, and ocular surface-related problems, primarily caused by an unstable tear film, producing symptoms of irritation, burning sensation or dryness.⁴⁶ Specific additional risk factors for eye-related problems in the office environment, besides indoor air quality, include office illumination, external glare sources and reflections, quality of the computer screen, and the design of the workstation.³²

A significant problem when investigating patient complaints of dry eye is that subjective symptoms and objective clinical signs do not correspond well.¹⁶ Moreover, the observation of the clinical signs typically takes place in a different setting from the workplace (the doctor/optometrist examination room). These issues can lead to un-intended mis-diagnoses of work-related dry eyes. Any symptoms, such as burning, dryness, gritty, itchy and stinging sensation, as well as scratchiness, soreness, blurry vision, strain and eye irritation, or asthenopia, need to be considered in context with the work-related indoor environment.⁴¹

3.2 Aim

The aim of this study was to investigate the prevalence of dry eye-related symptoms arising from the use of electronic devices in highly visually-demanding reading/computer work in a modern, open-plan flexible-working office, without local control of air-conditioning. This paper reports on a study

that investigates the types of dry eye symptoms at work and at home, the influence of the environment and the influence of dry eye symptoms during the working day.

3.3 Methods

Using a cross-sectional design, 2 web-based questionnaires (A and B) were developed. Survey A consisted of 14 questions and was designed to investigate the eye symptoms experienced during daily activities at work and the impact of the symptoms on daily activities in a modern office environment, using forced-choice questions and Likert scales. Survey A also investigated the type and prevalence of eye symptoms experienced both at work and at home, the number of working hours per day, and the types of visual tasks during the day, such as reading from hard copy, computer, laptop, or smartphone. The type of contact lens or spectacle correction was recorded, specifically what was used for reading, and subjects were asked to rate their overall general health. The survey also asked about the subject's knowledge of their working environment, air-conditioning, adjustable light systems, daylight and airflow. The content of Surveys A and B can be found in the appendices.

Survey B was designed as an optional extension of the investigation by asking questions on whether the subject had consulted with an eye care professional for their dry eye symptoms or if they were using any current therapy. The survey consisted of 4 questions, as well as 12 questions on symptoms using the Dutch culturally-translated version of the Ocular Surface Disease Index (OSDI). Both surveys were initially designed in English, and then translated into Dutch. Approval was given to use the validated English and Dutch OSDI for this research. A categorised score of the OSDI was used in the statistical analysis: normal ocular surface (0-12 points), mild (13-22 points), moderate (23-32 points), or severe (33-100 points) ocular surface disease.¹⁴¹

Survey B also included the Dutch cross-culturally-translated Illness Perception Questionnaire (IPQ) (adapted for dry eye) which contains 8 questions, and subjects completed the Dutch version (adapted for dry eye) of the Work

Productivity and Activity Index (WPAI). However, only 2 (of the 6) questions were analysed for this study: Q5; The impact of dry eye on productivity while working, rated on a visual analog scale of 0 (dry eye had no effect on my work) to 10 (dry eye totally prevented me from working), and Q6; How much did dry eye affect your ability to do your regular activities, other than work at a job?, rated on a visual analog scale of 0 (dry eye had no effect on my activities) to 10 (dry eye totally prevented me from performing my regular activities).

3.3.1 Recruiting participants

Subjects were recruited from 3 different office environments: (1) Technical University, (2) University of Applied Sciences, (3) City Hall in the Netherlands. All of the locations were selected because they used a flexible workspace office design, meaning that all workers experienced similar working conditions, and all workers were primarily employed in computer-based work.

For Survey A, all of the subjects were recruited using the same participant information, a general office-wide email and by posting of information on the office intranet. A reminder email was sent after 2 weeks, and again after 1 month. Inclusion criteria were participant age between 18 to 65 years and to have worked at the location for at least 3 months. Subjects at Locations (1) and (2) received their request for participation during a restricted period between May and September 2014, and the employees at Location (3) were invited to participate between September and November 2014.

For Survey A and B, participants with diagnosed Sjögren's syndrome were excluded. This specific, rare, auto-immune disease has a proven impact on lowering the quality of life. No other general health issues were asked or excluded.

At the conclusion of Survey A, subjects with dry eye symptoms were invited to complete Survey B. If they agreed, the subject was sent an Internet web-link for the survey directly to their email address. A reminder to participants to respond to the questionnaire was sent after 4 weeks.

For both surveys, the participant was asked to give informed consent at the start of the survey before being able to continue. The study was approved by the Human Research Ethics Audit Committee of the School of Optometry and Vision Sciences at Cardiff University and was consistent with the tenets of the Declaration of Helsinki. Both surveys were hosted on www.surveymonkey.com.

3.3.2 Location specifics

Location 1 at the technical university is called a 'living lab'. It is a renovated building, which is the home of the Department of Architecture, Building and Planning, and it is designed so that research and test environments in real-life situations are set up. The indoor environment is measured every 10 mins for relative humidity (Rh)(%), temperature (°C), CO₂ (ppm), and air speed (m/s).

A pilot was completed to look at dry eye symptoms in workers during the day, matched with measurements of the indoor environment during the working day, over the 10th and 12th of June 2014. On both days, outside RH and temperature were high, yet the building indoor environment met the criteria for a "very good" building (NEN-ISO 7730). The internal temperature over the two days was within 23-26°C, RH was between 30-50%, CO₂ was less than 500ppm, and the air stream was, on average, <0.12 (m/s). The CO₂ measurements are indicative of how well the ventilation performs. For the two other two locations (2 and 3), no measurements were taken of the indoor environment and so these specifics were not known, except that central heating and air-conditioning systems were used at the two locations.

3.3.3 Statistical methods and analysis variables

The analysis included all participants completing Survey A at the three different locations, and all participants who completed Survey B. Statistical comparisons of the total score, as well as per location, were made for Survey A. Data was compared using Pearson's chi-square test. Repeated-measures analysis of variance (one-way ANOVA) was used, and trend tests were performed via linear regression analysis to compare age and dry eye diagnosis. Mann-Whitney U Test was used to analyse gender and diagnosis, and for multiple

comparisons and ranking, the Kruskal-Wallis test was used for any non-parametric data. Associated eye symptoms at work and at home were analysed with McNemar. A p-value of <0.05 was considered to indicate a statistically significant difference. All statistical analyses were performed using IBM SPSS Statistics 22.0 (Armonk, NY: IBM Corp).

3.4 Results

3.4.1 Prevalence, severity and management of dry eye

In total, 556 responses were collected from Survey A. The results are summarised in Table 3.1. There was no significant difference in age between the three different locations (Kruskal-Wallis, $p=0.311$). There was no significant difference in the number of hours spent working per day between the locations, although there was a significant difference in the working hours per week (Kruskal-Wallis, $p<0.000$), with subjects at Location 1 working more working hours per week (full-time employees) than the other two locations.

No statistically significant difference was found in the form of spectacle prescription used by the participants at the three locations. In general, health was rated as good and very good, with a statistically significant difference between locations (Kruskal-Wallis, $p=0.005$). General health (Kruskal-Wallis, $p<0.005$), mean rank Location (2) 227.5, showed a slightly lower positively-rated general health than the other two locations (1) 259.4 and (3) 269.8, respectively. Consequently, the data of the populations were combined for further analysis.

More females participated in the study than males at all locations. Almost one-third of participants reported that they had been diagnosed with dry eye (30.1%), of which 79.7% were diagnosed by their optometrist. There was no significant gender difference in the declared diagnosed dry eye (Pearson Chi-square, $p=0.300$). Direct logistic regression was performed to assess the impact of aging on the likelihood of dry eye diagnosis ($p=0.034$; odds ratio = 1.019), which indicated that the odds of diagnosis increases by 1.9% each year (from 18-65 years).

In total, 213 participants completed Survey B (Table 3.2). No record was made of the subject location as the survey was open to all participants with eye symptoms and dry eye symptoms. A higher proportion of females (76.1%) completed Survey B, similar to Survey A. Furthermore, a statistically significant difference in age distribution for males and females was observed, with the mean age of males higher than females (Kruskal-Wallis $p=0.002$). A statistically significant relationship was found between gender and the severity of dry eye symptoms, as categorised with the OSDI, with higher scores in females (one-way ANOVA, $p=0.000$). No statistically significant difference was found between age and the OSDI score (Kruskal-Wallis, $p=0.206$).

Table 3-1 Survey A, Demographics data of participants.

*Percentage exceeds 100% as multiple responses were possible for the participants.

Survey A		N=505
Female % (n=355)		70.3%
Age, mean (sd), years		44.47 (11.2)
	Location 1: 43.65 (1.48)	
	Location 2: 44.09 (0.86)	
	Location 3: 45.45 (0.67)	
Working hours per week		33.79 (8.84)
Working hours per day		8.08 (1.78)
Diagnosed dry eye (%)		30.1
Diagnosed by gender (%)		28.0 (M) 32.7 (F)
Diagnosed by (%)		
	GP	12.2
	Optometrist	79.7
	Ophthalmologist	8.1
General health (%)		
	Excellent	16
	Very good	37.2
	Good	40.4
	Fair	5.7
	Poor	0.6
Prescription used (%)*		
	Glasses distance	26.3
	Glasses multifocal	22.4
	Computer glasses	13.5
	Reading glasses	20.2
	Contact lens; Distance	18.0
	Contact lens; Multifocal	4.2
	Contact lens; Monovision	2.8
Inhibition during the day diagnosed with dry eye, yes/no %		
	Not at all	Y (6.3), N (37.9)
	Occasionally	Y (41.5), N (38.4)
	Sometimes	Y (43.4), N (20.5)
	Most of the time	Y (8.8), N (2.0)
	Always	Y (0), N (1.2)
Of all reading tasks during the day, they read from:		
	Desktop	60%

Hardcopy	16%
Laptop	9.8%
Tablet	9.3%
Smart phone	1.3%
Environment (Yes, No) (%)	
Air conditioning	Y (57.6), N (42.4)
Central heating	Y (86.6), N (13.4)
Air stream	Y (79.1), N (20.9)
Window that can be opened	Y (36.2), N (63.8)
Daylight or daylight lamps	Y (80.2), N (19.8)
Adjustable light available	Y (18.5), N (81.5)

Whilst two-thirds of the respondents (66.6%) reported mild to moderate symptoms with the OSDI, less than 40% were using any treatment. In contrast, some participants with a normal OSDI score were using treatments. The most commonly-reported traditional dry eye treatments included: artificial tears, ointments, warm compresses and lid hygiene, with some participants using a combination of treatments. Less conventional treatments included homeopathic eye drops and tap water drops.

Over two-thirds of Survey B respondents (69.5%) reported that they had not consulted any of the listed professionals for their eye symptoms. The total number of consultations exceeded the participants, as some had consulted more than one professional. From the suggested professionals, the optometrist was visited the most often, however the number of participants who marked the option 'Others' (e.g. optician, drugstore, pharmacy) exceeded those who consulted an optometrist (Table 3.2).

3.4.2 Working environment

Participants reported spending the majority of their working time on a desktop computer (60%). Much lower proportions of time were spent reading from a hardcopy (16%), laptop (13%), smartphone (9.8%) or tablet (9.3%) (Table 3.1).

The presence of air conditioning and central heating were reported by 57.6% and 86.6% of the participants, respectively, whilst a high proportion experienced the presence of an airstream (79.1%). A high proportion of the participants were not able to open a window at their workplace (63.8%). Whilst the majority of the

participants experienced the presence of natural daylight or daylight lamps (80.2%), they do not have access to adjustable light at their workspace (81.5%).

A desktop computer was the most used device for reading during the day. Location 3 showed a trend towards a greater use of tablet and smartphone. Location 1 showed a trend of using computers for reading more often than the other locations, but it was not significantly different.

Table 3-2 Survey B: Demographics data of participants.

Survey B		N=213
Female %		76.1
Age group (%)		
18-30		14.6
31-40		23.5
41-50		28.6
51-60		27.2
61-65		6.1
OSDI score, n=197 (%), F (%)		
Normal		33.3, F (20.2)
Mild		22.7, F (16.7)
Moderate		17.6, F (14.6)
Severe		27.7, F (22.7)
Used treatment (%)*		
Artificial tears		19.7
Ointments		3.3
Warm compresses		3.3
Lids scrubs		1.4
Nutrition		1.4
Other		10.3
None		60.6
Consulted professionals (%)*		
GP		8.92
Optometrist		20.67
Ophthalmologist		12.21
OHP		1.41
Other		26.29
None		69.50

*The percentage exceeds 100% as some participants used a combination of treatments and/or consulted several professionals.

Participants reported that they felt a number of different factors were responsible for their symptoms of dry eye including: indoor climate (44.2%),

general health (15.5%) (including allergy, hormones, genetics), work environment (14.2%), and reading and computer use (12.5%). These were followed by visual comfort (8.3%), contact lens use/refractive surgery (6.7%) and external factors (2.5%).

3.4.3 Ocular symptoms at work and inhibition of work

In order to assess the impact of the work environment on ocular symptoms, participants were required to report the frequency of various symptoms experienced throughout the day, whilst at work and at home. With the exception of 'tearing' and 'stickiness', participants experienced significantly more symptoms at work compared to home (McNemar's Chi-square test, $p=0.326$ and $p=0.163$, respectively) (Table 3.3). High positive percentage of symptoms were found at work for stinging (58.5%), burning (60.5%), irritation of the eyes (62.7%), blurred vision (53.0 %) and transient vision (50.2%) were experienced, although itching (44.8%), tearing of the eye (34.9%) and photophobia (38.3%) followed next in high percentages of symptoms at work (see Figure 3.1).

Table 3-3 Comparison of experienced eye symptoms during the working day and at home.

Symptoms work vs home	Total p-value*
Stinging	0.000
Burning	0.000
Irritation	0.000
Itching	0.000
Tearing	0.326
Stickiness	0.163
Pain (in the eye)	0.000
Pain (around the eye)	0.001
Photophobia	0.000
Blurry vision	0.000
Transient vision	0.000

*Values in **bold** are significant, McNemar, $p<0.05$

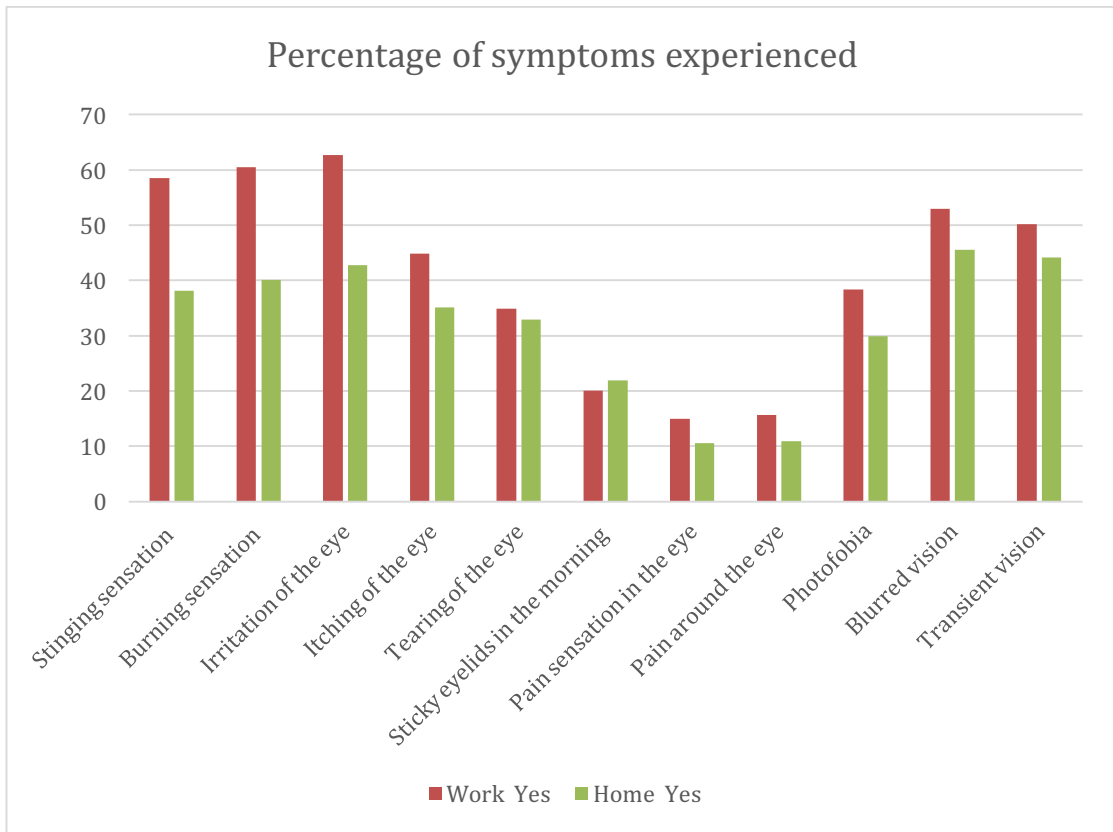


Figure 3-1 Symptoms experienced at work and at home in percentage of the participants of all 3 locations

More than two-thirds of participants experienced some inhibition of their daily work activities from eye symptoms, with over 5% experiencing symptoms most or all of the time (Table 3.1). Participants diagnosed with dry eye experienced significantly greater inhibition of daily activities from eye symptoms than those without dry eye. A statistically significant difference was found (Mann-Whitney U Test, $p=0.000$) between those diagnosed with dry eye ($n=159$) mean rank 325.88 and non-diagnosed ($n=346$) mean rank 219.51).

Overall, females diagnosed with or without dry eye experienced more inhibition of their daily activities from eye symptoms than males (Mann-Whitney U Test, $p=0.03$; males ($n=151$) mean rank 232.91; females ($n=354$) mean 261.57).

The results from the Work Productivity and Activity Index (WPAI) and Illness Perception Questionnaire (IPQ) indicated some statistically significant gender differences.

Table 3-4 Work productivity and activity index outcome

Work productivity and activity index		N			
			Mean	Sd	P value
<i>During the past seven days, how much did dry eyes affect your productivity while you were working? (Score 0 means Dry eyes had no effect on work, Score 10 means Dry eyes completely prevented me from working)</i>	Man	25	2.96	2.57	0.039
	Female	57	4.26	2.60	
	Total	82	3.87	2.90	
<i>During the past seven days, how much did dry eye affect your ability to do your regular daily activities, other than work at a job? (Score 0 means dry eyes had no effect on your daily activities, Score 10 means that dry eyes completely prevented you from doing your daily activities)</i>	Man	25	3.00	2.50	0.258
	Female	57	3.31	2.60	
	Total	82	3.86	2.97	

Overall, females diagnosed with or without dry eye experienced more inhibition of their daily activities from eye symptoms than males (Mann-Whitney U Test, $p=0.03$; males ($n=151$) mean rank 232.91; females ($n=354$) mean 261.57).

The results from the Work Productivity and Activity Index (WPAI) and Illness Perception Questionnaire (IPQ) indicated some statistically significant gender differences.

Females reported higher levels of impact on their work productivity (mean: 3.35 sd 2.53; $p=0.039$, Mann-Whitney U Test) compared to males. However, no difference was reported for daily activities excluding work (mean male: 2.76 sd 2.60; mean female: 2.75 sd 2.60; $p=0.258$, Mann-Whitney U Test) (Table 3-4).

Gender differences were also reported with the IPQ question “How much does your dry eyes affect your life?” ($p=0.040$, Mann-Whitney U Test,) with females reporting a greater effect. The other IPQ questions about the helpfulness of the treatment, the emotional effect, and how good they understand their disease, showed that participants were concerned about the helpfulness of treatment (mean 4.24, sd 2.86; with 0 meaning ‘not at all’ and 10 ‘very helpful’). Dry eye had a more limited effect on the participants emotionally however (mean 4.04,

sd 2.98; with 0 meaning 'not at all' and 10 'extremely affected'). The participants report some level of understanding of their disease with a mean score of 5.75 (sd 3.16) for understanding the dry eye illness (0 meaning 'don't understand at all' and 10 'understand very clearly') (Table 3-5).

Table 3-5 Illness perception questionnaire

		N	Mean	Sd	P value
How much does your dry eyes affect your life? <i>Score 0 means no effect at all.</i> <i>Score 10 means severely affect my life</i>	Man	23	3.17	2.5	0.040
	Female	50	4.30	2.64	
	Total	73	3.95	2.63	
How long do you think your dry eyes will continue? <i>Score 0 means a very short time</i> <i>Score 10 means forever</i>	Man	23	5.96	3.62	0.931
	Female	48	5.96	2.83	
	Total	71	5.96	3.08	
How much control do you feel you have over your dry eyes? <i>Score 0 means absolutely no control.</i> <i>Score 10 means extreme amount of control.</i>	Man	23	4.52	3.15	0.664
	Female	49	4.06	2.73	
	Total	72	4.21	2.86	
How much do you think your treatment can help your dry eyes? Please tick the box below. <i>Score 0 means not at all.</i> <i>Score 10 means extremely helpful.</i>	Man	22	4.09	3.19	0.473
	Female	49	4.30	2.73	
	Total	71	4.24	2.75	
How much do you experience symptoms from your dry eyes? <i>Score 0 means no symptoms at all.</i> <i>Score 10 means many severe symptoms.</i>	Man	22	4.18	2.77	0.188
	Female	48	5.10	2.73	
	Total	70	4.81	2.75	
How concerned are you about your dry eyes? <i>Score 0 means not at all concerned.</i> <i>Score 10 means extremely concerned.</i>	Man	22	3.27	2.66	0.274
	Female	49	4.18	3.12	
	Total	71	3.90	3.0	
How well do you feel you understand your illness? <i>Score 0 means don't understand at all.</i> <i>Score 10 means understand very clearly</i>	Man	21	5.52	3.27	0.679
	Female	48	5.85	3.14	
	Total	69	5.75	3.16	
How much does your dry eyes affect you emotionally? (e.g. does it make you angry, scared, upset or depressed?) <i>Score 0 not at all affected emotionally.</i> <i>Score 10 extremely affected emotionally.</i>	Man	22	4.05	2.80	0.950
	Female	49	4.04	3.09	
	Total	71	4.04	2.98	

3.4.4 Symptom differences per location

Participants working at Location 3 experienced significantly more eye symptoms than the other locations. Location 1 showed a statistically significant difference in asthenopic complaints, such as ‘stinging’, ‘burning’ and ‘irritation of the eye at work vs home’, that might be explained by long durations of computer work.

Table 3-6 Symptoms experienced at work vs home per location.

Symptoms work vs home / location	(1) p-value	(2) p-value	(3) p-value
Stinging sensation	0.021	0.004	0.000
Burning sensation of the eye	0.039	0.004	0.000
Irritation of the eye	0.021	0.001	0.000
Itching of the eye	0.508	0.030	0.000
Tearing of the eye	1.00	0.851	0.135
Sticky eyelids in the morning	0.625	0.070	1.00
Pain sensation in the eye	1.00	0.700	0.010
Pain around the eye	1.00	0.012	0.023
Photophobia (light sensitivity)	1.00	0.007	0.000
Blurry vision	0.125	0.064	0.001
Transient vision	1.000	0.118	0.001

*Values in **bold** are significant, McNemar, $p < 0.05$

Considering the use of eye drops, in those participants who had been diagnosed with dry eye, shows a limited use in general, and a significant difference depending on location. Participants diagnosed with dry eye at Location 3 showed a tendency of not using any eye drops, with 41% not using any eye drops during the day. No option was given to assess the use of alternative therapies. Of the diagnosed dry eye participants of Survey A at Location 3, 41% were not using artificial tears. The percentage using therapy by “non” diagnosed participants was higher at Location 1 than at the other locations.

3.4.5 Inhibition at work per location

At Location 1 there was no statistically significant difference between type of

inhibition experienced between males and females (Pearson Chi-square, $p=0.472$), despite statistically significant differences at Locations 2 and 3 (Pearson Chi-square, $p=0.035$, $p=0.014$) in favour of more inhibition experienced by females (Table 3-7).

Table 3-7 Demographic data per location of survey A

Data Survey A	Location				P-value
	(1)	(2)	(3)	Total	
Age (n)	57	187	260	504	
Mean	43.65	44.09	45.45	44.70	0.331 Δ
sd	11.165	11.715	10.848	11.215	
Gender (n)	57	187	264	508	
Male	29.8%	20.3%	29.7%		0.001 \blacklozenge
Female	70.2%	79.7%	70.3%		
Diagnosed with dry eye (n)	63	195	283		
Yes	19.0%	11.3%	47.0%	30.1%	0.000 \blacklozenge
No	81.0%	88.7%	53.0%	69.1%	
Healthcare professional who diagnosed Dry Eye					
GP	16.7%	9.1%	10.5%	10.5%	0.000 \ddagger
Optometrist	33.3%	72.7%	73.7%	70.7%	
Ophthalmologist	41.7%	18.2%	2.3%	7.2%	
Diagnosed with Sjogren's Syndrome	8.3%	0.0%	13.5%	11.4%	
Who diagnosed Dry Eye, excluding participants diagnosed with Sjögren's syndrome					
GP	18.2%	9.1%	12.2%	12.2%	0.000 \ddagger
Optometrist	36.4%	72.7%	85.2%	79.7%	
Ophthalmologist	45.5%	18.2%	2.6%	8.1%	
Working hours per week (n)	37.56	34.62	32.51		0.000 Δ
sd	10.43	9.36	7.62		
Working hours per day (n)	7.83	8.18	8.05		0.261 Δ
sd	0.136	0.325	0.60		
General health (n)	55	187	263		
Excellent	9.1%	19.8%	14.8%		0.005 Δ
Very good	47.3%	42.8%	31.2%		
Good	34.5%	33.2%	46.8%		
Fair	9.1%	2.7%	7.2%		
Poor	0.0%	1.6%	0.0%		

Inhibition on daily activity (n)	54	184	254		
Not at all	18.5%	33.2%	24.8%		0.024 ♦
Occasionally	35.2%	39.7%	40.9%		
Sometimes	40.7%	22.8%	28.7%		
Most of the time	1.9%	4.3%	4.7%		
Always	3.7%	0.0%	0.8%		
Inhibition daily activity Man vs Female					
	M n=148	F n=344			P=0.007 ♦

Summary of demographic results from Survey A (♦ Pearson Chi-square test, Δ P Kruskal-Wallis, ◇ Mann-Whitney U Test, ‡ Fisher). Values in **bold** are significant $p < 0.05$.

3.4.6 Perception of work environment per location

The perception of the work environment, air conditioning, central-heating, airstream and window that can be opened, was not equal between the locations (Pearson Chi-square, $p < 0.000$). The presence of air conditioning was almost equal for Locations 1 and 2, while Location 3 showed a higher positive response (63.9%). For central heating, a lower positive response was seen at Location 3 (80.2%). A higher percentage of participants experienced airstream at Location 3 (near 90%) than at the other two locations (Location 1 (72.2 %) and Location 2 (67.2%)).

The presence of a window that could be opened was answered negatively by 95% of participants at Location 3, while at Locations 1 and 2, the value was approximately 30%. There was also a significant difference in having daylight or a daylight lamp (Pearson Chi-square, $p = 0.027$). Location 1 (90.7%) showed the highest score for having daylight or daylight lamps (Location 2, 82.8 % and Location 3, 76.2%). Having an adjustable light at the desk was highest at Location 1 (29.6%), and the lowest at Location 3 (16%), but there was no significant difference in having an adjustable light at the desk (Pearson Chi-square, $p = 0.064$) (Table 3-6).

		(1) %	(2) %	(3) %	Pearson Chi square
There is air conditioning	yes	48.1	42.3	63.9	P=0.000
	no	51.9	57.7	36.1	
There is central heating	yes	92.6	94.1	80.2	P=0.000
	no	7.4	5.9	19.8	
There is an air stream	yes	72.2	67.2	89.1	P=0.000
	no	27.8	32.8	10.9	
There is a window nearby that can be opened	yes	72.2	69.4	4.7	P=0.000
	no	27.8	30.6	95.3	
There is daylight or daylight lamps	yes	90.7	82.8	76.2	P=0.027
	no	9.3	17.2	23.8	
There is adjustable light at the workplace	yes	29.6	18.6	16	P=0.064
	no	71.4	83.4	84	

Values in **bold** are significant, $p < 0.05$.

Table 3-8 Environment perception per location.

3.5 Discussion

Eye-related problems in a digital environment can arise from a range of possible causes related to environmental factors, visual demands, blink-rate, tear film quality, ergonomics, and the well-being of the individual. A difficulty in managing these problems arises from limitations in the understanding of the subjective assessment of the symptoms. This study contributes to the general understanding of work-related dry eye by investigating the symptoms reported in a cohort of office workers, working in a modern, digital office environment.

3.5.1 Reported diagnosed dry eye

The number of participants with reported diagnosed dry eye was found to vary between locations (range 19-47%). These percentages are high, compared with those of Uchino et al. (2008), who reported that approximately 14% of 3549 office workers were clinically diagnosed with DED.⁵³ In a second study by Uchino et al. (2013), the prevalence of dry eye was 8% for men and 18.7% for women, with a mean age of 43.3 ± 9.1 years.³⁶

The prevalence of workers with dry eye in this study is possibly higher due to the fact that participants who had a previous assessment of dry eye by a GP

and/or diagnosed dry eye by an optometrist were maybe more intrigued to participate.

3.5.2 Use of reading materials

All participants used electronic devices for reading during the day. As expected, the desktop computer was used most often, followed by the laptop. The impact of using electronic devices for reading is in debate. The use of the smartphone as a work-related reading device seems to be more common these days, and reading text from a smartphone has also been linked with asthenopia.¹⁴² Several investigators have found a decreased blink-rate, an increased incomplete blink-rate, tear film instability, and/or significantly increased symptoms of blurred vision when reading from a computer screen compared to reading from hard copy.^{20,49,143} The effect from the use of a tablet or smart phone, and how that affects any symptoms, is not well understood by either employees or employers.

The respondents at all locations agreed that they did not have access to local, adjustable light at their workplace. For a fixed, working location, the impact of light and the ability to adjust for its impact around the workstation to match the needs of the individual worker is known to have a positive impact, leading to a reduction in the reporting of SBS symptoms.¹⁴⁴ In a modern work environment with the use of flexible working workplaces, the adjustment of the screen for contrast and intensity has to be personalised. Knowledge of visual discomfort caused by reflections from a computer screen does not appear to be a “standard” ergonomic instruction. However, this should be as common as adjusting the chair and desk to the ergonomically-advised standards. As reported in the study by Long et al. (2014), cooperation between optometrists and the health and safety services (the in-office ergonomist), or another ergonomist expert, is important to promote better visual comfort and productivity for the aging population.¹³¹ Evidence suggests that eye care practitioners are inconsistent with giving advice about the environmental impact on ocular comfort and this is therefore an area that needs addressing.¹⁴⁵

3.5.3 Symptoms

In Survey A, nearly 70% of participants reported some inhibition of daily activities due to eye symptoms. Whilst there was no gender difference in reported dry eye diagnosis by a clinician, females reported increased levels of inhibition compared to males. Eye symptoms, such as 'stinging', 'burning sensation', 'itching' and 'irritation of the eyes', were reported statistically more frequently at the work place than at home by all participants.

Respondents to Survey B appeared to be aware of the impact of the environment on ocular comfort, and reported that indoor climate and the work environment were both key causes of developing dry eye. Localised airflow, dry air climate conditions, allergens and environmental pollution are known to exacerbate the total risk of discomfort during visual tasks while wearing contact lenses, so there is an established link between environmental conditions and discomfort.³²

In Survey B, a statistically significant difference was found between gender and the severity of dry eye symptoms, as categorised with the OSDI. This may be biased due to self-selection, nevertheless this is a much higher proportion and a younger prevalence than would be expected in the general population. Female participants, in particular, also reported higher levels of impact on their work productivity. The results of an online survey by Patel et al. (2011) showed increasing levels of impairment in the ability to perform daily activities and a reduction in productivity while at work with increasing severity of DED.⁷¹ Furthermore, the IPQ showed that females felt that dry eye affected their life significantly more than the male participants. These findings are in line with those of Stenberg et al. (1995) and Bakke et al. (2008), who report that women had more complaints about environmental perception and a lower tear break-up time.^{146,147}

An increased awareness of the level of inhibition reported by females may be a point of interest in the diagnosis and management strategies for healthcare professionals. Results from the IPQ indicate the participants felt they did not have much control over their dry eyes (mean score: 4.21), or felt that their

treatment was not very helpful (mean score: 4.24). Given the high proportion that had not consulted an eye care practitioner about their symptoms, it is possible they are not using the most effective treatment or management strategy. This could potentially lead to stress and anxiety, and even depression,^{67,148} which could lead to reduced work productivity or even sick-leave. In contrast, 95% of patients who have had DED care found that the treatment had been helpful.¹⁴⁹ The observation that participants consulted the pharmacist and/or alternative therapy more often than the healthcare professional with their dry eye symptoms also needs to be investigated more.

3.5.4 Limitations

A challenge in preparing this study was to find locations with similar reading tasks during the day and similar office work environments. However, localised adjustments of the workplace environment might be more instinctively performed in a work location with a technical background (Location 1), since they are interested in the technical aspects, or in a healthcare teaching environment (Location 2), since they are more likely to be aware of the impact of environment on health. This potential ability of the workers was not taken into account. Also, there is a possible bias arising from the tendency of people to participate when experiencing problems. Participants were only required to rate their general health, rather than answer in detail about other ocular diseases or diagnoses that may impact their vision. Therefore, any underlying ocular disease could have influenced the outcome of the illness perception and work productivity answers.

The survey did not reveal any indirect health-related dry eye that would be detected from the use of certain medication. Whilst dividing the surveys into 2 parts provided extra information, it may have led to question fatigue, with the consequence of a reduced response rate for Survey B. A further issue could be that participants did not categorise their eye symptoms as dry eye and so did not feel the need to fill in Survey B. Differences in interpretation of the questions might also have caused an effect, where any technically educated participants might interpret the definition of air-conditioning more rigidly than

others who perhaps considered it an office cooling system. However, even with the possible limitations, the investigation identified the need for understanding the possible eye-related problems and the inhibition of work activity during the day.

3.6 Conclusions

In this investigation, the impact of dry eye symptoms, in terms of inhibition of daily activities at work, showed that more than two-thirds of the participants experienced some inhibition, with over 5% experiencing symptoms most or all of the time. Furthermore, the impact on work productivity and effect on life were all significantly higher for females. Symptomatic workers are not consulting occupational physicians, with the majority of respondents reporting using self-medication or self-cure as alternative therapy, even in preference to eye care professionals, such as optometrists or ophthalmologists.

The experience of eye symptoms during the working day in an office setting can be a multi-disciplinary problem. For the working population with dry eye in modern offices, the first step could be gaining a multi-disciplinary understanding of dry eye across a range of specialists, including the optometrist, ergonomist, OHP and GP. This may encourage better awareness of how eye-related tasks and working environments in modern offices can aggravate eye-related symptoms. This would lead to a new approach to understanding what is a healthy environment for office workers, which, in turn, could lead to more awareness of the needs of the physical surroundings designed by architects.

3.7 Next step

This study on the type and prevalence of dry eye-related symptoms arising from the use of electronic devices in a modern, open-plan flexible-working office, and the possible impact on work-related daily activities, was focused on the tasks done during the day and, partly, on the indoor environment. But what if the work-related dry symptoms progress to a chronic state, or the symptoms continue after work? Could these discomfort symptoms affect work productivity, and workplace environment satisfaction? And what is the social impact from eye

discomfort after working hours on the quality of life experienced by someone with work-related DED?

The workers at Location 3 scored high on prevalence of dry eye symptoms and scored high on diagnosed dry eye, which suggests an influence from the indoor environmental quality (IEQ). To answer this question, the next chapter reports on a study looking at the occupational perception of IEQ, and the possible social impact of symptoms after work-time, for workers in open-space office areas with dry eye related symptoms.

Two articles based on this research have been published:

van Tilborg MM, Kort HSM, Murphy PJ, Evans KS. The influence of dry eye and office environment on visual functioning. *Stud Health Technol Inform*, 2015; **217**: 427-431.

van Tilborg MM, Murphy PJ, Evans KS. Impact of dry eye symptoms and daily activities in a modern office. *Optom Vis Sci* 2017; **6**: 688-3

4 Eye discomfort symptoms of office workers; social impact and perception of environment

4.1 Study 2: Introduction

There is an increasing awareness of the impact of dry eye disease (DED) as a public health concern. The personal and economic consequences of having DED are thought to be under-estimated, and are receiving increasing attention as a result.^{30,115} The type and variety of personal impact on the quality of life, such as decreased work productivity, illness perception, anxiety, and even depression, gives DED an influence on not only the physical aspects of daily life, but also on the emotional and social aspects.¹¹⁶ As a result of decreased productivity from DED in the workplace, it is estimated that the economic burden exceeds the direct cost of care.^{31,74,115}

The Dry Eye Workshops Report (DEWS), in 2007, gave a definition of dry eye as: *“Dry eye is a multifactorial disease of the tears and ocular surface that results in symptoms of discomfort, visual disturbance, and tear film instability with potential damage to the ocular surface. It is accompanied by increased osmolarity of the tear film and inflammation of the ocular surface”*.¹² For office workers, dry eye can occur as a part of computer vision syndrome (CVS). CVS includes all eye and vision problems associated with use of a computer screen, which may include eyestrain, headache, ocular discomfort, dry eye, diplopia, and blurred vision.⁴⁷ It is believed that computer work causes eyestrain, promotes a reduction in blink-rate or an increase in incomplete blinks, a reduced tear stability, and can be indirectly responsible for dry eye symptoms in the subject.^{49,150}

In the workplace, these latter factors have a variable impact, with the principle influence on their severity thought to arise from environmental factors and computer use. It is known that, when working on a desktop computer, increased evaporation of tears from the exposed ocular surface can occur. When this occurs in an office environment with a low relative humidity (RH <40%) and/or an air draft (1.5m/s), it can cause an even higher evaporation rate from the tear

film.³⁸ This is often called the 'desiccating stress of the eyes'. In turn, this desiccating stress leads to increased tear instability, which promotes further evaporation, and a recurring cycle of tear instability, evaporation and surface desiccation.³⁹ This stress cycle initiates an inflammatory process that will produce symptoms, cause damage to the anterior surface of the eye (cornea and conjunctiva), and decrease the production rate of tears. Individual workers can also have other ocular pathologies which can contribute to the reduction in tear stability or production. For example, blepharitis (an eyelid margin disease) is more often seen in people in areas with air pollution, and it is thought that indoor air determinants or pollution of the indoor air can promote its development or increase its severity.⁴⁰

The WHO International Classification of Functioning and Disabilities (ICF) looks at the relationship between health and symptoms, and the influence of environmental factors on daily activities and the social participation of individuals.¹⁵¹ ICF identifies the building-related environmental factors as humidity, temperature, light conditions and acoustics.

For this study, building-related environmental factors are relevant, since workplace humidity and air temperature, and the presence of an air-draft, are thought to be significant influences on the development of the signs and symptoms of DED.^{38,39} However, age is also a factor and may have an increasing effect on the incidence of symptoms as the retirement age of workers increases.⁷² Within ICF, age belongs to the personal factors which might influence daily activities and participation.¹⁵¹

In the Netherlands, the ISO Standard for 'Ergonomics of the Thermal Environment' (NEN-ISO-7730:2005)⁴ is used as a method for predicting the general thermal sensation and degree of discomfort. The thermal comfort is described as a personal expression of satisfaction with specific aspects of the

NEN-ISO-7730 (2005), "Ergonomics of the thermal environment – Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria", available at:

environment, including air temperature, radiant temperature, air velocity, humidity, clothing and activity.

Climate standard conditions for buildings, such as temperature, ventilation air stream, air humidity, and carbon dioxide (CO₂), as described in NEN-ISO-7730:2005, are categorised as: A, very good; B, good; C, acceptable. For relative humidity (%), 'very good' means a relative humidity range between 30-50%, 'good' between 25-60%, and 'acceptable' between 20-70%. However, Yokoi et al. (2015) stated that, despite the indoor environment in buildings complying to the standard of being within "acceptable air quality standards", it is very likely that some of the workers in these buildings suffer from unrecognised DED,³⁷ since the climate standard does not provide an 'unacceptable' condition for buildings.

When problems of dry eye symptoms at the workplace exist, several professionals can be involved with the management of the symptoms: GP, optometrist, and ophthalmologist, as well as the OHP, health and safety consultant, and employer. The question can be raised, when work-related dry eye exists, of whether there is a link between satisfaction of the workplace environment and any work-related symptoms that continue to influence the employee after work.

The results from the surveys reported in Chapter 3 found that there was a negative influence on work productivity and daily activity at work from eye symptoms experienced at work for a large percentage of workers (70%).¹⁵² The study also found that dry eye-related symptoms were experienced, statistically significantly, more often at work than at home ($p < 0.05$) (stinging, burning, irritation, and itching of the eye) and that there was a statistically significant ($p < 0.05$) difference between at home and at work for pain sensation in the eye around the eye, for light sensitivity blurry vision and transient vision. As can be seen by computer vision syndrome or work environment related.

4.2 Aim

The aim of this explorative investigation was to gain knowledge of the indoor environmental quality (IEQ) as experienced by workers in a modern design, open-plan, office building, and how this is related to the ocular surface disease index (OSDI), any possible social impact, and the gender of the workers. Furthermore, possible influences from seasonal variations were investigated.

4.3 Methods

4.3.1 Location

This study was undertaken at a government office building (built in 2003) with a history of indoor environmental air quality issues over more than 10 of the previous years. The highly architecturally-valued building consisted of a 4-story structure, covered with a glass façade, which faced towards the south. The building contained an open-plan office space. A recent (2013) renovation was performed to create more flexible-working workstations, meeting rooms and hall spaces. Nearly 600 employees work for this organisation, of whom nearly 400 work primarily at this location.

4.3.2 IEQ measurements

Measurements of indoor air quality were taken before and during recruitment of participants for this investigation. Measurements were recorded using indoor measurement stands at 2 locations on the second floor of the building, at the south corner, over a 3-week period (26 November to 15 December 2015). During this time, the instruments measured temperature (supplied air, air temperature, radiation temperature), air quality (CO₂, relative humidity (%RH), airflow speed (m/s), particle counter (ppm), and light (radiation W/m²), every hour, at desk height.

4.3.3 Recruitment procedures

All employees (n=400) working in the open-space office building, between 18-65 years of age, were invited to participate. All participants were invited by email via the intranet and could indicate their interest to participate directly with the

researcher or by making an appointment centrally at the reception desk. Participants signed a consent form at a preliminary recruitment visit, at which they made an appointment for the first visit. At the preliminary visit, subjects were screened for inclusion: pregnancy or breastfeeding, Sjögren's disease, refractive surgery within the last six months, and working less than 4 months at this location were exclusion criteria for this investigation. The clinical investigation was conducted between January-May 2015 and was composed of assessment of workplace IEQ satisfaction, ocular symptoms (OSDI), and their impact on social aspects. Participants attended on two separate days.

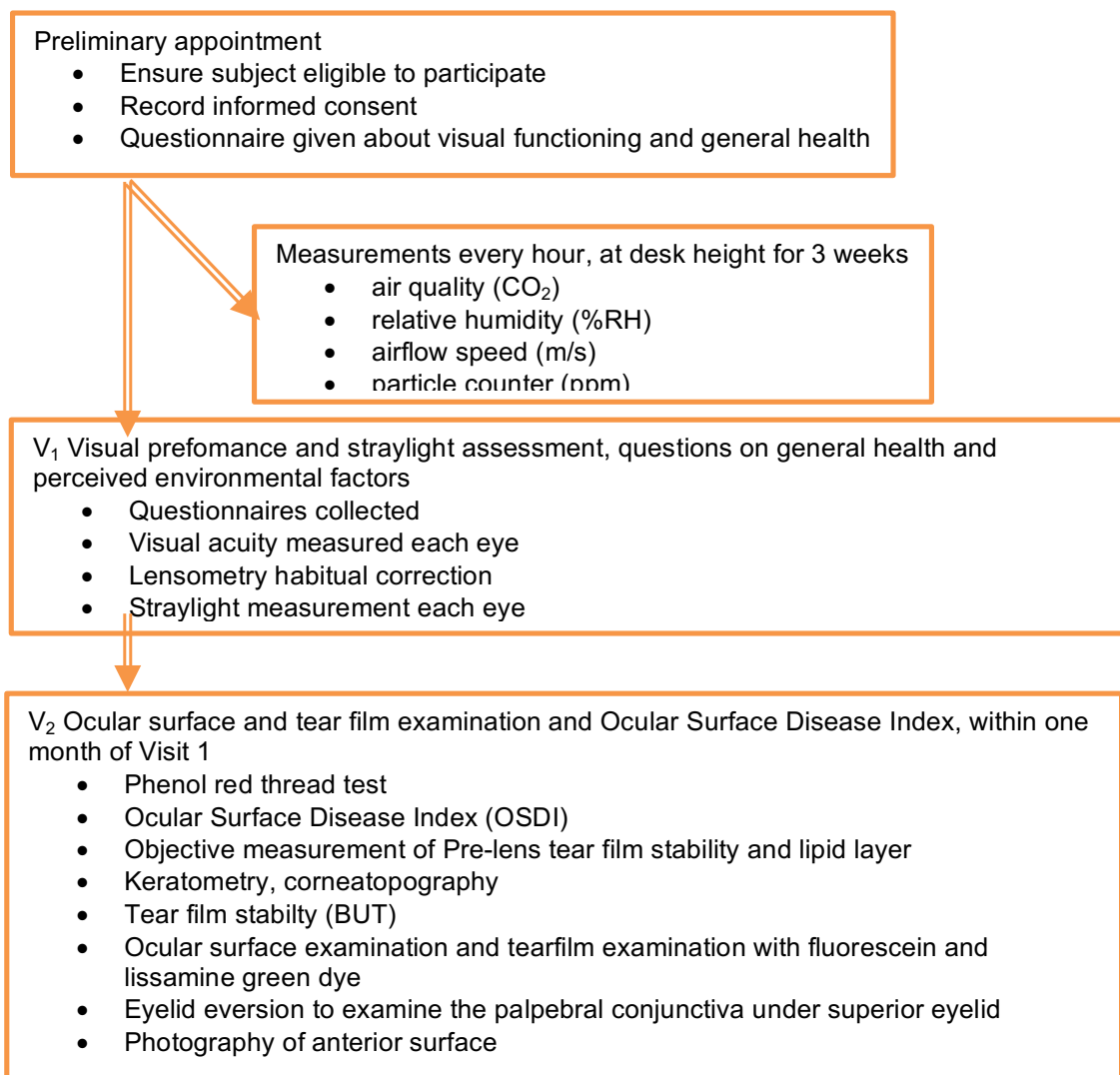


Figure 4-1 Flowchart investigation

First Visit; Visual performance, straylight assessment, general health and perceived environmental factors.

Visual acuity (VA) was measured for distance and near, with the habitual correction, using an EDTRS logMAR chart at 6m. Participants were asked to bring along the specification of any current glasses and/or contact lenses. Any habitual corrections were focimetered and the ocular refraction determined by auto-refractor measurements taken without wearing contact lenses. Straylight measurements (Oculus C-Quant, Oculus GmbH, Germany) were taken for both eyes while wearing any corrective lenses. If wearing spectacles, the habitual correction was only needed when the VA reached a level of 0.5 or lower.¹⁵³

Two questionnaires (Table 4-1, 4-2) were given to each participant to fill in at home and bring to the second visit. The English version of the questionnaire with the perceived environment questions was cultural translated into Dutch. The first questionnaire asked about general health, the last medical examination, last exam by an eye care professional, any drug prescriptions, allergies and specific vitamin or superfood intake.

Table 4-1 Set of questions; Ocular history, General health

<i>Ocular History (Refractive)</i>
The following questions are about your glasses:
Please write your prescription if known for both eyes.
What type? (single vision, multifocal, etc.)
How old are the glasses? (in years)
Mode of wear? (full / part time, distance / near / both)
What is the quality of the vision with the prescription?
Are there any problems with the present prescription?
Do you use any specific visual requirements for work or recreation?
<i>If you are using contact lenses please fill in all the questions below:</i>
If you know the power of the contact lenses please write them below
Do you know your brand of contact lenses you are wearing, if so please note this below
How old is the current pair of lenses?
Can you provide the mode of wear?
Can you provide the current solutions you use for the lenses?
Quality of vision with prescription?
Any problems with your current contact lenses?
<i>Ocular History (Health)</i>
Any current or past eye health problems, such as (Please ✓ the right answer)
Injuries
Trauma
Surgeries
Strabismus (eye turn)
Amblyopia (lazy eye)
Vision therapy or orthoptics

Glaucoma Cataracts
The last eye exam.
When was your last eye exam? (Open question)
Who performed it? (Please ✓ the right answer)
My optician My contact lens specialist My optometrist My ophthalmologist
General Health History
Are you in good health? (Open question)
Do you have (Answer yes/no)
High blood pressure, Diabetes Mellitus type 1 Diabetes Mellitus type 2 High Cholesterol
Medications
Do you use any medication and if so would you give the type of medication and what they are used for.
Allergies
Do you have any allergies at all?'
Supplements
Do you use any supplements such as vitamins, fish oil or special "super food"
Can you provide the supplements, or other, you are taken

The second questionnaire contained a 5-point forced-choice Likert Scale, from very satisfied to very dissatisfied, with a neutral point in the middle, asking about perceived occupational IEQ, such as their satisfaction of the light conditions(daylight and electric light), air temperature, humidity at their workstation, and perception of the sonic environment during the summer and winter, as well four questions asking about the interference or enhancement of the environment (air quality, light condition, acoustic quality and air temperature) on getting their work done. The last three open questions asked to whom they reported the impact of any eye-related problems and building-related problems (IEQ), and the possible impact on their social life (Table 4-2).

Table 4-2 Set of questions; perception and impact of eye-related problems

Demographic questions and questions about perception of IEQ at workstation, workplace and building, and of the social impact of eye-related problems and building-related problems.

1) What is your gender?

Second Visit; Ocular surface and tear film examination, Ocular Surface Disease Index

The second visit occurred within 1 month of the first visit and started with collection of the questionnaires. Contact lens wearers were given the instruction to not wear their contact lenses on the day of the examination. Tear film quantity was then measured, before the general and ocular history, and questions about any eye symptoms experienced during the day of the examination.

During this visit, the participant was also asked to fill in the OSDI questionnaire (Allergan), which asks about any symptoms experienced during the last week. This specific dry eye disease questionnaire has 3 sub-sections: Part 1 asks about ocular symptoms, Part 2 about inhibition of daily activities, such as reading or working on a computer, and Part 3 about symptoms due to environmental factors, such as wind or drafts. Forced answers were: 'none of the time', 'some of the time', 'half of the time', 'most of the time', or 'all of the time'. By adding the OSDI scores, the outcome can be scored between 0 to 100, with a higher score indicating more problems or symptoms.

Two groups were classified according to the outcome of the OSDI (Group A: Normal-Mild score ≤ 22 ; Group B: Moderate-Severe score ≥ 23).

4.3.4 Ethical approval

The study was approved by the Human Research Ethics Audit Committee of the School of Optometry and Vision Sciences at Cardiff University, and was consistent with the tenets of the Declaration of Helsinki. In the Netherlands, this investigation was seen as a routine optometric investigation by the Medical Research Involving Human Subjects Act. All data was filed confidentially and kept anonymous at the point of data entry, with no subjects identifiable in any presentation.

4.3.5 Statistics

Descriptive statistics were performed on patient demographic data (age, gender, health status and OSDI score). All statistical analyses were performed

using IBM SPSS Statistics 24.0 (Armonk, NY: IBM Corp). The answers to the questions on working years in the building and time working at the workstation were analysed with the Chi-square test. The environmental perception (satisfaction/dissatisfaction) questions about air quality, humidity, and light conditions (Table 4.1) were analysed by gender (male/female), and by OSDI group score (A/B). These groups were classified according to the outcome of the OSDI (Group A: Normal-Mild score ≤ 22 ; Group B: Moderate-Severe score ≥ 23). Mann-Whitney U tests were performed to test any differences between males and females and OSDI score. The Independent sample test (t-test) was performed to analyse the perception scores by comparison between OSDI groups. A Cronbach's Alpha coefficient of the 21 questions was conducted to look at internal consistency. A Cronbach's Alpha coefficient should ideally be above 0.7 for good consistency. Logistic regression was performed for gender and dry eye diagnosis, reported as an odds-ratio (OR) with the 95% confidence interval (CI).

4.4 Results

4.4.1 Participants, general health and OSDI score by gender

At visit 1, visual acuity and stray light measurement were taken of 112 participants, from a workforce of 400, after this "eye test" only sixty-eight workers proceed for the clinical examination. However, due to missing data (n=4 males), 64 subjects were included in the analyses: 4 participants did not complete the questionnaires. Of the 64 participants, 34% were male (n=19) and 66% female (n=45). Between 25-65 years of age, the mean age was 47.7 years (sd 9.3) (95% Confidence Interval for Mean, 45.3-50.0). For age category 18-30 years (n=3; 2 females and 1 male), for age category 30-50 years (n=46; 36 females, 10 males), and for age category 50-65 years (n=15; 7 females, 8 males).

The OSDI score for males (n=19) showed that 57% had a normal OSDI score, 4% had severe dry eye, 9% moderate and 30% mild. For females (n=45), only 18% had a normal OSDI score, 38% severe, 26% moderate and 18% mild (p<0.005). Females showed a higher predictor for having more severe dry eye

symptoms, with an Odds Ratio (OR) of 2.745 ($p < 0.001$, S.E. 0.299, Wald 11.493, 95% CI: 1.533 to 4.948).

No statistically significant difference was found for working years at the building and working at a specific workspace by gender, or by OSDI score.

Questions answered about ocular and general health showed no difference between gender, except for ocular trauma (such as, blunt trauma and/or removed foreign bodies of the cornea), with male participants reporting more ocular trauma than female respondents.

4.4.2 Visual acuity and staylight

The VA of the participants had a noticeable spread at distance and near with the use of the habitual correction. According to the guidelines for OHPs, a VA for distance under 0.1 logMAR needs a referral for refraction, meaning that nearly half of the participants needed to be referred (Figure 4.1). The guidelines also advise the need for computer glasses if the VA is lower than 0.2 logMAR, and over 20% of participants were found to have a near VA that needed a referral for computer glasses (Figure 4.2).

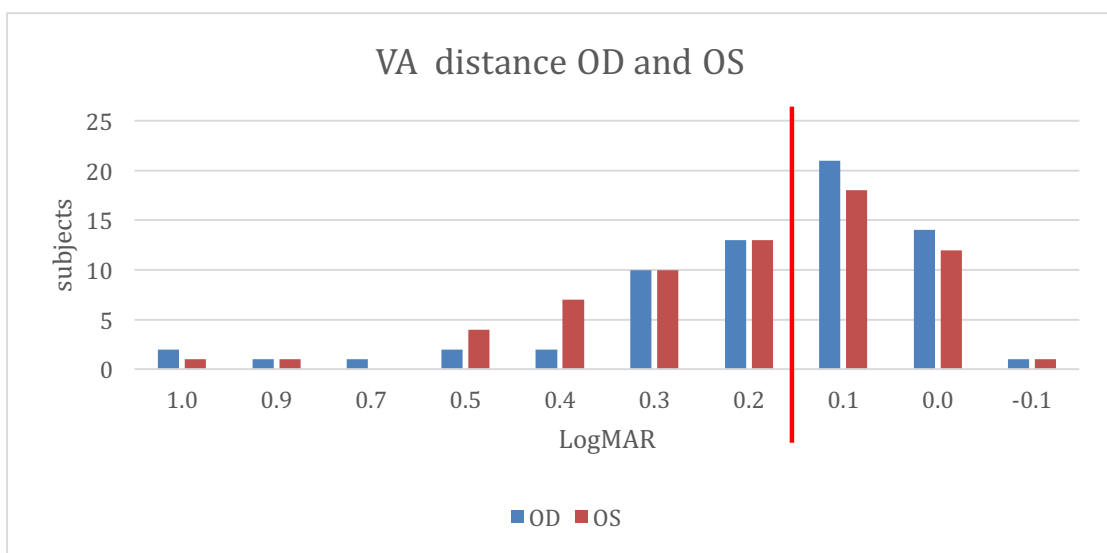


Figure.4-2 Distance VA of subjects for right eye (OD) and left eye (OS)

Distance VA of subjects for right eye (OD) and left eye (OS); the red line represents the guideline for OHPs that a VA of lower than 0.1 logMAR requires a refraction for new glasses.

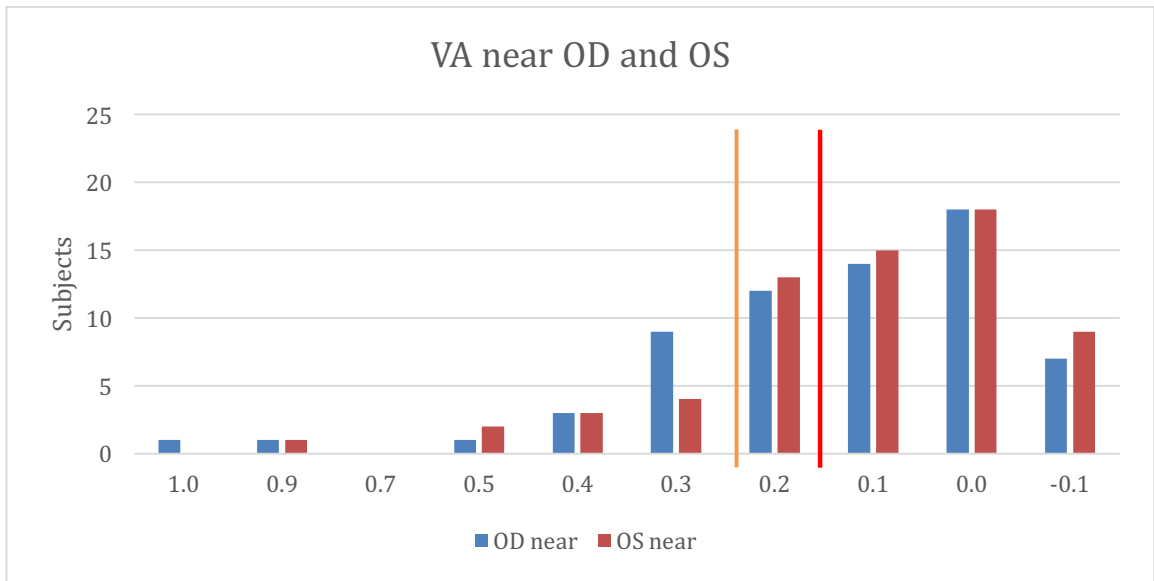


Figure 4-3 Near VA of subjects for right eye (OD) and left eye (OS) with habitual correction
 Near VA of subjects for right eye (OD) and left eye (OS) with habitual correction, the green line represents the guideline for OHPs that recommends wearing computer glasses when the VA is lower than 0.2 logMAR, and the red line represents the guideline that a VA of lower than 0.1logMAR requires a refraction for new distance glasses.

The straylight measurements showed a near normal distribution with age meaning that no cataract or other corneal pathology is causing stay light. (Figure 4.3).

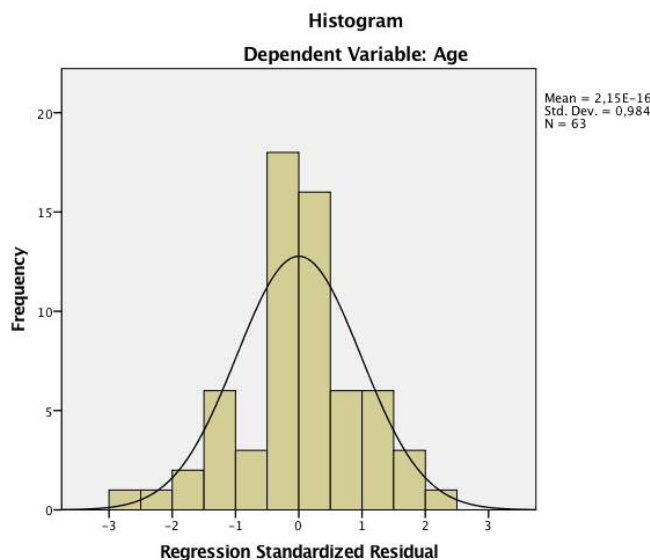


Figure.4-4 Distribution of Straylight measurement outcome and age.

4.4.3 Occupational perception by gender

Looking at the internal consistency of the general questions about the perception of the IEQ (21 questions), at their workstation and in the building, a

strong internal consistency was found, with a Cronbach's Alpha coefficient reported of 0.923.

No significant difference was found in grading of satisfaction of the environment between males (n=19) and females (n=45), except for the degree of satisfaction with air quality at workstation (p=0.016), air temperature in the winter (p=0.027), constancy of temperature in the winter (p=0.018), and satisfaction with the quantity of daylight in the winter at their workstation (p=0.046), with a greater dissatisfaction by females on these comparisons.

4.4.4 Occupational perception by OSDI Group

When the cohort was classified according to OSDI score, 2 equal groups were produced: Group A: Normal-Mild (n=32) and Group B: Moderate-Severe (n=32). No statistically significant differences were found between the 2 groups for the number of working hours per day (p=0.565), per week (p=0.361), or in the years of working at this location (p=0.451).

Independent sample t-tests revealed a statistically significant difference, with a more negative score for Group B grading more dissatisfaction with humidity in the summer (p=0.008) and winter (p=0.004), the electric light and daylight conditions in the summer (p=0.005 and p=0.038, respectively), electric light conditions in the winter (p=0.045), and the visual comfort of the lighting (p=0.007). All other questions did not show a significant difference between Group A and Group B (Table 4.3).

Table 4-3 Comparison of satisfaction of IEQ between each OSDI Group, and difference in score: Group A – Group B.

Comparison of satisfaction of indoor environment quality per OSDI group	Mean Difference between OSDI Group	Std. Error of Difference	95% Confidence Interval of the Difference		P
			Lower	Upper	
How satisfied are you at your workstation in the <u>winter</u> (scale 1-5) with the:					
humidity?	-0.656	0.220	-1.095	-0.217	0.004
air stream?	-0.469	0.260	-0.989	0.052	0.077
air temperature?	-0.344	0.260	-0.864	0.177	0.192
constancy in temperature?	-0.344	0.257	-0.858	0.171	0.187
quantity of day light?	-0.500	0.304	-1.108	0.108	0.105
quantity of electric light?	-0.531	0.260	-1.051	-0.012	0.045
visual comfort of the lighting?	-0.469	0.253	-0.975	0.037	0.069
How satisfied are you at your workstation in the <u>summer</u> (scale 1-5) with the:					
humidity?	-0.594	0.215	-1.023	-0.164	0.008
air stream?	-0.469	0.264	-0.997	0.059	0.081
air temperature?	-0.325	0.276	-0.877	0.227	0.244
constancy in temperature?	-0.490	0.269	-1.028	0.048	0.074
quantity of day light?	-0.594	0.279	-1.152	-0.035	0.038
quantity of electric light?	-0.719	0.250	-1.218	-0.220	0.005
visual comfort of the lighting?	-0.665	0.237	-1.139	-0.192	0.007
How satisfied are you, in <u>general</u>, at your workstation (scale 1-5) with the:					
sonic level in the building?	-0.313	0.258	-0.828	0.203	0.230
surrounding sound in the building	-0.438	0.266	-0.970	0.095	0.106
air quality?	-0.469	0.251	-0.970	0.032	0.066

4.4.5 Individual light control at workstation

When looking at the ability to control light conditions at the workstation, 63 participants had no control over a light switch, 0 participants had control using a light dimmer, 4 participants had control over the light at their workstation using a desk lamp, and over half of them (n=34, 53%) answered that they had no control of sunlight by using a computer sunscreen.

4.4.6 Social impact of eye or building-related problems

The workers' occupational perception of the environment and the possible social impact were assessed by asking three open questions: "With whom do you discuss eye-related problems?", "With whom do you discuss building-related problems?", and "Can you explain how these problems interfere with your social life?".

Over 40% of participants did not discuss their eye-related problems with colleagues or family, nearly 53% reported that they discussed their eye-related problems with colleagues, nearly 7% discussed their eye-related problems with their spouses, nearly 9% with their supervisor, and nearly 3% discussed it with their optician (Figure 4.5a). Whilst the building-related issues were discussed most often with colleagues (nearly 60%), a small proportion also discussed their building-related issues with the Occupational Health and Safety (OHS) expert or working consultant (nearly 9%), and facility services (nearly 2%) (Figure 4.5b).

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For the social impact, the answers were categorised into 3 groups: Group 1: No impact, answered by nearly 31% of participants; Group 2: Not much impact, meaning that the complaints were limited, and diminished when being at home, answered by nearly 33% of participants; Group 3: A significant physical and emotional impact, reported by 38% of participants (Figure 4.5c).

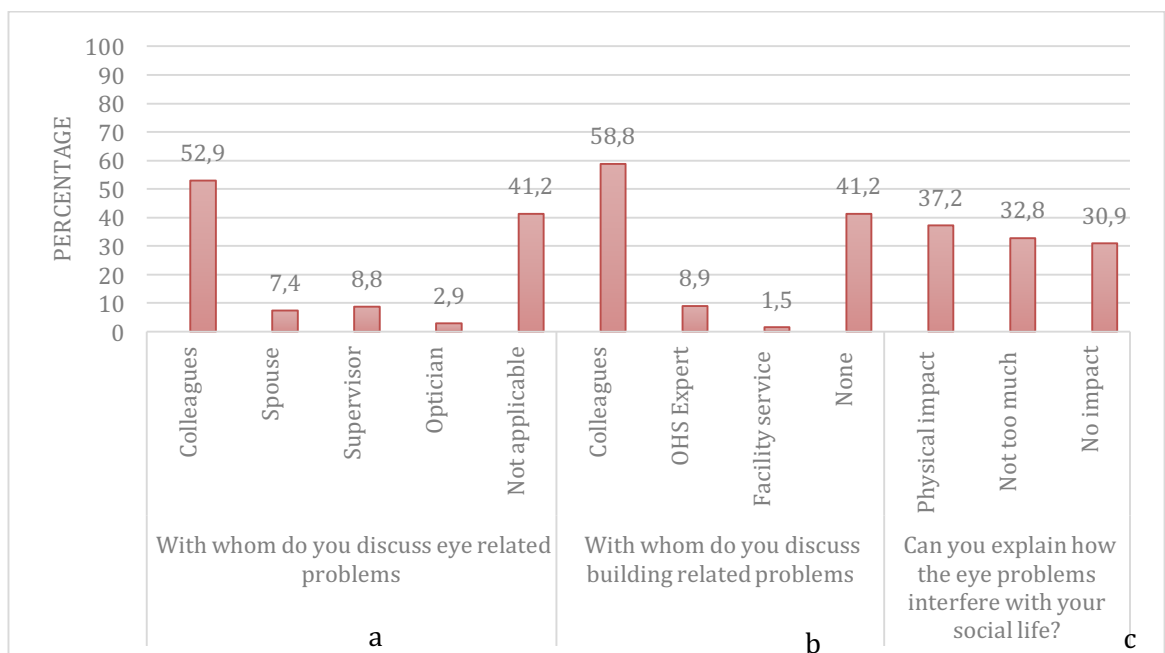


Figure 4-5 Social impact Social impact of eye or building-related problems.

Answers reflecting the physical and emotional impact were diverse, but mostly were tiredness (too tired, meaning lacking energy for a social event) headache, not able to watch television or i-pad/ tablet, not able to drive, or it was a reason to go to bed early. A small number said that they were not able to wear contact lenses (2%). More than a third said that they needed the weekend to recover from their work-related eye problems.

4.4.9 Environment

During the 3 week period, in winter time, the outdoor temperature and the indoor climate were assessed continuously by monitoring the outdoor and indoor air temperature, peak air temperature, operative temperature and relative humidity. Overall the indoor environment felt, according to the NEN-7730:2005 standard (winter), in category good. But the fluctuation between days and hours shows a difference, that would influence the perception of the indoor climate. As at a sunny day (outdoor temperature did not differ with a cloudy day before and after) the indoor air temperature just fell within Category C (acceptable) as the peak temperature at a sunny day was 24.67°C, as also did the air flow speed (up to 18m/s), and the CO₂ level (up to 900ppm) and humidity < 20 %. Overall the relative humidity was low below 30% as the temperature was between the 20-24 degree (°C) the level of CO₂ was high during the whole time and the airstream varied with the indoor temperature and sun radiation. (Table 4-4).

Table 4-4 NEN-7730:2005 limits for offices.

NEN 7730 category	A) Very Good	B) Good	C) Acceptable
Indoor temperature (°C)	Summer: 23 - 26	Summer: 23 – 26	Summer: 22 - 27
	Winter: 20 - 24	Winter: 20 - 24	Winter: 19 - 25
Air humidity (%)	30 - 50	25 – 60	20 - 70
Air stream (m/s*)	Summer: <0.12	Summer: <0.19	Summer: <0.24
	Winter: <0.10	Winter: <0.16	Winter: <0.21
Amount carbon dioxide (CO ₂) (PPM**)	<500	<900	<1100
*m/s= metres per second **PPM= particles per minute			

4.5 Discussion

In 1989, 47 office buildings in the UK were studied for building-related symptoms (Hede, et al., 1989). They found a significantly higher prevalence of building-related dry eye symptoms in workers in air-conditioned buildings with windows that could not be opened by the worker, than in those with openable windows. In the nearly 30 years since then, our understanding of the factors affecting dry eye symptoms has increased, but the application of this basic

finding (that poor air quality in buildings has an impact on ocular health) on the management of dry eye or the design of buildings has not been made. As an example, the test location for this study was an architecturally-valued building, built in 2003, but with a long history of indoor environmental air quality issues over more than 10 of the previous years.

Many studies have shown that office humidity and light conditions can be of crucial value to dry eye patients: A decrease in humidity promotes evaporation from the tear film, and tear film stability is adversely affected by computer-use, since workers blink less frequently²⁶. The impact of low humidity on the stability of the tear film is reported to be an important factor in subjective complaints.¹⁵⁴ Also, glare, either discomfort glare or disability glare, can interfere with the blink-rate, as well as cause eyestrain, further compounding the problem. Light sensitivity, discomfort glare and disability glare are known symptoms for moderate to severe DED.⁵⁴ The study of van de Wouw (2016) showed a higher mean straylight log's for dry eye patients than the age related mean straylight log's, no correlation was found with the van Bijsterveld score of staining.⁶² Irregularity of the tear film is also seen by Koh et al. (2017) as the explanation for increased straylight measurements.¹⁵⁵

In view of the link between environmental quality, the tear film and worker symptoms, and the lack of published studies on the impact of this on patient well-being, this explorative study investigated the perception of IEQ experienced by workers, grouped by gender and by observed DED symptoms. The results from the survey in Chapter 3 at this location (n=263) found that work productivity and daily activity at work were compromised by dry eye symptoms experienced at work for a large percentage of workers in the building (n=193, 74%).¹⁵² This study extends the previous study to investigate how these workers felt about the IEQ at work.

The first significant finding was that females were more significantly dissatisfied with the IEQ (air quality, ambient temperature and constancy of temperature in the winter) than males. This matches with the gender difference related to thermal comfort reported by Kim et al.¹⁵⁶ Although for the other issues asked

about there was no difference, the report of an increased sensitivity for air quality and ambient temperature suggests a confirmation of the known link for females and dry eye, since, as reported earlier, air quality and ambient temperature are linked with dry eye.^{157,158}

Secondly, when a comparison in IEQ perception between OSDI group was considered, different aspects became evident. There were differences in reported satisfaction with humidity in the summer ($p=0.008$) and winter ($p=0.004$), satisfaction with the quantity of electric light and daylight in the summer ($p=0.005$ and $p=0.038$, respectively), electric light in the winter ($p=0.045$), and satisfaction with visual comfort under general lighting ($p=0.007$). Generally, participants in OSDI Group B (Moderate/Severe) were less satisfied than the participants in OSDI Group A (Normal/Mild). These results may be explained by the low relative humidity in the building, especially during winter-time, and the possible lowering of relative humidity produced by an increase in temperature due to solar radiation. DED patients are known to report more discomfort glare than symptom-free individuals, and so the luminous effect of sunlight may have an impact on discomfort and disability glare.^{56,60} This can ultimately result in disability glare, and to the more severe, but rare, condition of photo-allodynia, which is caused by a chronic neurotrophic pain.⁶⁹

When office workers complain about the indoor climate, the standard response is to record indoor air quality measurements. For this study, during the recording period, the overall indoor air quality was categorised as 'good to acceptable', conforming with the Dutch Building Code Guidelines (NEN-ISO-7730:2005), under the Working Conditions Act (ARBO wet) issued by the Ministry of Infrastructure and Environment Guidelines. The relative humidity measurements were low (<30%), which is within acceptable limits, but on the few sunny days during that time period, there was a greater fluctuation in temperature (up to 24.7°C), humidity (minimum 18%) and airflow (maximum 0.18m/s). The values for relative humidity were below the designed value (40%), but they fell, on average, within the acceptable category (20-70%). It is known that low humidity levels (5-30%) can increase the prevalence of dry eyes

in office environments.^{21,159} Airflow higher than 1.5m/s and with a relative low humidity (RH <40%) is known to cause higher evaporation of the tear film and the indoor quality can be questioned to be interfering with the health status of eyes of the employees.³⁸ The higher CO₂ level also links with headaches or tiredness that may be part of the impact of eye symptoms at the end of the day.¹⁶⁰

Air draft is a known factor for causing higher evaporation from the tear film, especially in an unstable tear film, with all the subjective complaints accompanied by it. In the earlier study, nearly 90% of participants in this building (n=263) experienced an air draft during the day.¹⁵² An air draft is also a known factor for occupational perception of discomfort as a result of the cooling effect, which seems to be similar for every age category.¹⁵⁹ Moreover, the work-related symptoms that can occur from high airflow causing a draft may also be affected by other workplace factors, such as the frequency of surface cleaning or the use portable humidifiers or other indoor determinants (e.g. biotic agents, such as endotoxin-inducing Sick Building Syndrome).³⁴

The consequence of these fluctuations in airflow is that the environmental quality could be overall acceptable according the guidelines, with the outcome that no intervention is made. So, by using the NEN-ISO-7730:2005 guidelines alone, the classification of the building cannot represent the occupational satisfaction of those who work in it who experience eye issues, since this is related to the micro-environment near the worker.

The third finding was that a large number of participants were found to have a significant VA deficit. The OHP Guidelines state that when distance or near VA, with the habitual correction, is lower than 0.1 logMAR, a referral for a full refraction should be made. For this study, 40% of the participants at near and over 50% for the distance, needed a referral for refraction. Since uncorrected or incomplete correction of refractive error is a known factor for eyestrain symptoms, the recommendation that all workers should have a regular eye examination for refraction seems obvious.

4.5.1 Impact on worker well-being

Negative illness perception, as experienced through unrecognised or untreated symptoms, can cause a harmful cycle in emotional status, as symptoms are normally the most common motivation for seeking help or care. The presence of these symptoms could contribute to an impaired Quality of Life (QoL).^{67,116,161} Problems can arise when the symptoms are discounted due to a lack in concordance between patient-reported symptoms and diagnostic outcome,¹⁶ or when the building-related influences for developing dry eye symptoms are not considered. There is therefore considerable value in paying more attention to the QoL results, and not just to the clinical findings, even when the problems are seen as being work-related and/or building-related.

This negative illness perception can be seen in the finding that nearly 60% of participants discussed their eye-related problems with colleagues and relatives, but only a small number of participants reported their eye-related problems to their supervisor, and almost none to the occupational health service. Thus, it could be that the impact of dry eye is seen as a problem that can't be fixed, or that there is a belief that the supervisor, the occupational health care assistance, or the working consultant are unable to intervene to change the health problem, or that there is a general lack of awareness in the workers of how these groups can act to bring help.

There may be some evidence for this in the low responses for discussion of any building-related issues with the working consultant (nearly 9%) or with facility services (nearly 2%).

This negative expectation for a positive intervention in the situation could create a negative state of mind in the workers, who may feel that they are not heard or taken seriously. Well-being is a state of mind that can be adversely influenced by dissatisfaction, stress or anxiety. Although studies cannot correlate objective dry eye tests with depression or anxiety, they do correlate with patient-reported dry eye symptoms.¹⁶²

4.5.2 Limitations

The investigation is from a single local Government building in the Netherlands, with a known history of complaints of the IEQ. Thus, the participants could be influenced by taking part in this investigation as a result of long-standing complaints. However, it can be argued that this location is representative of modern, glass façade buildings with open plan office spaces, and is not a unique architectural set-up. Also, the participants could be biased towards a more severely-affected sub-type, as revealed by the even distribution of subjects between the two OSDI score groups. However, this even distribution strengthens the statistical analysis, and even with a small subject cohort, the investigation shows the social impact and satisfaction of IEQ. The limitation of a single location and small cohort size can be addressed by future studies at other office sites.

4.5.3 Practical Implications

No specific eye-related treatment strategies were being employed in the building, beyond individual workers' attempts to find relief through prescribed or over-the-counter artificial tear therapies. Instead, the commonly-used occupational guidelines (2013) for "computer work" were applied. These relate to the prevention of eye problems, or address complaints in seeing, and are focused mainly on managing good vision (VA), the prevention of arm and shoulder complaints (by improving ergonomic posture by using the appropriate chair height and computer distance), reducing sedentary work and physical inactivity, and the prevention of stress from new technologies or information overload. No other appropriate preventive occupational strategies were found by the investigator. As it seems no formal requirements for thermal indoor air are listed in the Dutch Working Conditions Act, a non-industrial office worker is entitled to no more than a workplace where climatic extremes are avoided.

However, even with the limitations of this investigation, some practical implications can be addressed. A holistic view of work-related dry eye is needed to address the factors that influence the symptoms the most. Worker awareness about the role of occupational services is needed to get the right help at the

right moment, as well as getting good clinical (optometric) diagnostic testing for these symptoms. Work-related dry eye symptoms should be seen as an occupational hazard in the office environment and need to be investigated at an early stage.

4.5.4 Conclusion

This study has created a better understanding about the perception and impact of the work environment on eye-related issues. The impact of having work-related eye problems, the relation to best corrected vision and social impact of work related eye problems needs to be investigated further, as the IEQ influences as light and humidity are significant and have an impact on the worker well-being away from work.

4.6 Next step

A negative social impact after working hours was reported from subjective eye discomfort and subjective work-place environment satisfaction. These could be of importance for general work satisfaction and productivity, as well as being a quality of life factor. When the symptoms occur more at work than at home, as Study 1 and 2 showed, and when even diminished symptoms can have a negative impact, prevention must be a key factor. However, if prevention is only focused on the environment, underlying general, ocular, health problems will not be discovered, and if any underlying ocular pathology is not diagnosed, eye discomfort will still occur, even if the environment is adjusted. To assess the relative impact of environment and ocular disease, it would be good to assess the clinical ocular findings in office-workers alongside measurement of the environmental parameters at one specific building.

An article based on this investigation has been submitted

van Tilborg MMA, Murphy PJ, Evans KS, Kort HSM. *Eye discomfort symptoms of office workers in an open-plan office; social impact and perception of the environment.*

5 Investigating clinical signs of dry eye disease in a modern, digital office environment

5.1 Introduction

Physical health can be influenced by working conditions. The environmental characteristics of office buildings are associated with dry eye complaints, with workers reporting improvement of symptoms away from the office.^{34,152} The European study of de Kluizenaar et al.³⁴ showed a prevalence for dry eye symptoms, over a four-week period, in 39.1% of office workers surveyed (n=1078), and Study 1 showed a prevalence of 30.1% in office workers (n=578) with diagnosed dry eye disease (DED), and a prevalence of 66.6% reporting mild to moderate ocular discomfort complaints.¹⁵²

Symptoms of DED can have a negative impact on daily activities at work, work productivity and quality of life. Study 1 found that up to 70% of examined office workers reported some inhibition in work activities, and over 5% experienced symptoms most or all of the time.¹⁵² Participants with a higher OSDI score experienced more negative impact on their daily activity and work productivity, such as not being able to drive or watch television, or needing a weekend away from work to recover. Over 30% of participants reported a social impact due to eye-related problems at work.¹⁵² A systematic review by McDonald et al. (2015) also found evidence to suggest that DED has a substantial, negative impact on the physical, and, potentially, the psychological state, function and quality of life of DED patients.¹¹⁵ Cox and Griffiths (1995) gave a definition of such psychosocial hazards as: *“those aspects of work design, and the organisation and management of work, and their social and environmental context, which may have the potential to cause psychological or physical harm”*.¹⁶³

In a modern, digital office environment, the temperature, humidity and airflow of the office area is typically under central control, and not modifiable by the employee. Higher workplace temperature, lower humidity and increased airflow are provocative factors for the development of DED symptoms.³⁵ When these factors are combined with a decreased blink-rate, it produces a desiccating

stress for the ocular surface. This desiccating stress leads to a reduction in tear film quality and quantity, which can initiate an inflammatory process that will increase the symptoms, cause damage to the anterior ocular surface, and decrease the production of mucin and tear fluid.^{34,99,115}

Since the environment can influence DED symptoms, working for a longer period of time in a sub-optimal office may increase the risk of their development. If this is combined with an aging population working in offices on highly-demanding visual tasks (since increasing age is a known factor that increases the incidence of dry eye symptoms), the risk of eye-related symptoms increases further.

Two further key issues when assessing workplace DED are that subjective symptoms and clinical signs do not correspond well,¹⁶ and that objective measurements for diagnosing dry eye typically take place in a different setting to the patient's workplace. This means that missed diagnoses of work-related dry eye disease could easily occur. With the possible negative social impact of the eye-related symptoms developed during work, it would appear that an accurate understanding of the prevalence of DED, tested in the workplace, and its causative factors, is important.

Moreover, since dry eye symptoms are associated with psychological and psycho-social factors (stress, depression, anxiety),^{67,164} and occupational stress lowers the threshold for eye irritation, there may be a negative impact on work productivity,¹⁶⁵ and on perceived happiness in daily activities at work, as a result of increased dry eye symptoms.¹⁶²

When there is a negative social impact from eye discomfort during the working day, and the subjective complaints are higher at work than at home, an overall negative impact on work activities can occur. When environmental complaints exists, the first reaction is to adjust the indoor air quality. This has merit, since the environment can cause DED, and thus cause a lower tolerance to indoor air quality.¹⁶⁶ However, chronic DED, caused by environmental factors, is believed to produce fewer symptoms, but more clinical signs.^{28,166} A clearer

understanding of the relationship between clinical signs, symptoms and the environment in office workers with chronic DED will assist in developing appropriate management, by both the healthcare professional and the worker.

5.2 Aim

The aim of this explorative investigation was to assess the subjective and objective clinical signs of dry eye disease, using an in-office examination, in a cohort of employees working in a modern-design, open-plan, office building.

5.3 Methods

This study was completed as part of the larger study reported in Study 2, but was limited to those volunteers who volunteered to participate in this explorative, observational, cross-sectional study, which was conducted between January and May 2015. The building was a modern, glass, open-office design, with flexible working practices, and had a history of internal investigations for compromised indoor air and environmental quality. The study was promoted by the employer to employees as an “eye screening” program to encourage participation during regular working hours. Participants were recruited by a message through the organisation’s general, digital messenger service, and via a general email sent to all employees. A reminder email was sent four weeks later. The participant responded with their interest to participate directly with the researcher or by making an appointment at the building reception.

5.3.1 Recruitment procedures

Subjects for this study were recruited as per the recruitment procedure in Study 2. All 400 employees between the ages of 18-65 years, working at a single local government building, were invited to participate in this extension of Study 2. Sixty-eight participants completed the clinical examination.

A detailed methodology of the investigation and the procedures used are described in Chapter 4.

5.3.2 Ethical approval

The study was approved by the Human Research Ethics Audit Committee of the School of Optometry and Vision Sciences at Cardiff University and was consistent with the tenets of the Declaration of Helsinki. In the Netherlands, this investigation was seen as a routine optometric investigation by the Medical Research Involving Human Subjects Act. Access to the data was secured using a login code and password. Only the researcher had access to the data. Data was kept confidential and made anonymous at the point of data entry, with no subjects identifiable in any presentation. The examination room was lockable and only accessible to the local floor manager and the researcher.

5.3.3 Clinical investigation

The clinical investigation was completed at the Visit 2 of Study 2. This visit occurred within one month of the first visit. Appointments were scheduled during regular working-day hours. Contact lens wearers were asked not to wear their lenses on the day of the examination.

A series of clinical tests were completed, starting with tear film quantity, measured using the phenol red thread (PRT) test (ZoneQuick, Menicon Ltd, Japan). The cotton thread was placed at the outer canthus of each eye (one eye at a time) for a period of 15 secs. The cotton threads were measured for tear wetting by observing the colour change in the thread. Wetting length was categorised as: Dry <10 mm, Borderline 10-19 mm, and Normal >20 mm.

Following the PRT assessment, and to allow the tear film to normalise after the procedure, the completed questionnaires were collected and the participant's general and ocular history were taken, along with questions about any eye symptoms currently experienced. Lastly, the participant was asked to complete a Dutch-language version of the OSDI questionnaire, which asked about any symptoms experienced during the last week. The total OSDI score was used to categorise each participant as having either none (<13), mild (13–22), moderate

(23–32) or severe (33–100) symptoms. These steps took approximately 10 mins to complete.

V₂ Ocular surface and tear film examination and Ocular Surface Disease Index, within one month of Visit 1:

- Case history
- Phenol red thread test
- Ocular Surface Disease Index (OSDI)
- Objective measurement of Pre-lens tear film stability and lipid layer
- Tear film break-up time (TBUT)
- Lid wiper epitheliopathy (LWE)
- Ocular surface examination and tear film examination with fluorescein and lissamine green dye
- Meibography
- Eyelid eversion to examine the palpebral conjunctiva under superior eyelid
- Photography of anterior surface

Figure 5-1 Clinical assessments completed on each subject.

Ocular surface quality was graded using the Oxford grading scales for corneal and conjunctival staining, with the use of two dyes: fluorescein and Lissamine green (HUB Pharmaceuticals, LLC, USA).^{167,88} The fluorescein tear break-up time (TBUT) was categorised as: Dry <5 secs, Borderline 5-10 secs, and Normal >10 secs.⁸⁰

Meibomian gland dysfunction (MGD) was assessed by expressing the inferior meibomian glands using a cotton swab, and grading the colour and viscosity of the meibum as: 0) clear meibum, easily expressed; 1) cloudy meibum, easily expressed; 2) cloudy meibum, expressed with moderate pressure; 3) meibum not expressible, even with hard pressure assessed at the central lower lid.¹⁶⁸

Superior and inferior lid wiper epitheliopathy (LWE) were graded, using the Korb grading method (2005), by taking the average of the horizontal length of the staining (in mm), and the average sagittal width of the lid-wiper, in percentage of the extension of the lid wiper proximate to the line of Marx to the sub-tarsal fold. Horizontal length of staining Grade 0 = <2mm, Grade 1 = 2-4mm, Grade 2 = 5-9 mm, Grade 3 = >9 mm and average sagittal width of staining were: Grade 0 = <25%, Grade 1 = 25% to 50%, Grade 2 = 50% to 75%, Grade 3 = >75%.¹⁶⁹

5.3.4 Statistical analysis

One experienced optometrist (MvT), specialised in anterior segment and dry eye assessment, performed all of the procedures. Descriptive statistics were performed on patient demographic data (age, gender, health status and OSDI score). Mann-Whitney U tests were performed to test any differences between males and females. The more severe measurement of the two eyes was used in the analysis of disease severity. Spearman correlation coefficients of determination were calculated (r^2) between the 11 measurement outcomes using SPSS 24 (IBM Corp., NY, USA), the correlations were categorised as weak (0.2-0.39), moderate (0.40-0.59), strong (0.60-0.79) or very strong (0.80-1.0).¹⁷⁰ The correlations were also compared between OSDI groups. These groups were classified according to the outcome of the OSDI; Group A: Normal-Mild score ≤ 22 ; Group B: Moderate-Severe score ≥ 23 .

5.4 Results

5.4.1 Demographics

A total of 68 participants completed both visits. Of the 68 participants, 23 (33.8%) were male (mean age: 48.09 years \pm sd 9.97) and 45 (66.2%) were female (mean age: 46.64 years \pm sd 9.17). In total, 46% had worked for up to 5 years in this building vs 54% who worked for more than 5 years. The majority (65%) of participants worked between 11-30 hours per week; 28.3% worked more than 30 hours per week and 6.7% worked less than 10 hours per week. No differences were found between gender of the working hours, time working at the building or at their workplace (Table 5-1).

5.4.2 General and ocular health

Questions on ocular and general health showed no difference between gender. Nearly 30% of participants reported having an allergy (20 of the 68 participants), and over half of this sub-group (5 female, 1 male) were using medication, such as anti-histamine tablets and/or drops, daily or seasonally. Only 4 participants (all female) reported use of artificial tears or a lubricating gel at night.

Of the 68 participants, 28 were referred for a refraction, based on their habitual corrected distance/near VA (binocularly lower than 0.8 decimal VA distance or near), and/or the auto-refractor outcome, and/or focimetry of the current prescription.

Table 5-1 Set of questions; Demographics data of participants

Age (years)	n	Minimum	Maximum	Mean	Sd	
Male	23	29	65	48.09	9.97	0.617
Female	45	25	65	46.64	9.17	

Age category (%)	18-30 years	31-50 years	50-65 years	Total	
Male	33.3%	28.9%	53.3%	33.8%	
Female	66.7%	71.1%	46.7%	66.2%	

How many years working in this office?					
	< 1 year	1-2 years	3-5 years	> 5 years	
Male	16.7%	50%	28.6%	32.4%	0.679
Female	83.3%	50%	71.4%	67.6%	

How long have you been working at your present workspace?					
	< 3 months	4-6 months	7-12 months	> 12 months	
Male	50%	25%	66.7%	35.9%	0.898
Female	50%	75%	33.3%	64.1%	

In a typical week, how many hours do you spend at your workspace?					
	<11 hours	11-30 hours	> 30 hours		
Male	25%	30.8%	52.9%	0.100	
Female	75%	69.2%	47.1%		

No statistically significant differences were found between genders in mean age, working hours per day, working hours per week, years working in the building and current workplace (Mann-Whitney, $p < 0.05$).

No differences were found between gender and VA for near or distance except for the VA distance OD. The male participants showed a lower average VA than the females ($p < 0.016$).

5.4.3 Ocular symptoms at time of the examination

At the time of examination, the most commonly experienced symptoms were ‘tired eyes’ (over 54%), ‘dry eye symptoms’ (nearly 32%), ‘irritation of the eyes’ (31%), and ‘asthenopia’ (29%). A less-frequently reported symptom was ‘stinging of the eyes’ (7%) (Table 5-2).

Differences in experienced symptoms by gender showed that females reported ‘tired eyes’ (62.2%), ‘burning eyes’ (48.9%) and ‘dry eyes’ (42.2%), followed by ‘asthenopia’ (37.8%). The males reported ‘tired eyes’ (39.1%), ‘blurry vision’ (21.7%), and ‘irritation of the eyes’ (26.1%). No statistically significant difference was found in the symptoms reported between gender, except for ‘dry eye symptoms’ and ‘asthenopia’, which were more frequent in females ($p=0.015$ and $p=0.034$, respectively) (Table 5-2).

Table 5-2 Symptoms experienced at eye examination

N=68	Overall (%)	Male (%)	Female (%)	P value
Dry eyes	32.4	13.0	42.2	0.015
Tired eyes	54.4	39.1	62.2	0.070
Itching	26.5	17.4	31.1	0.225
Burning	42.6	30.4	48.9	0.145
Blurry vision	25.0	21.7	26.7	0.657
Stinging	7.4	4.3	8.9	0.497
Irritation	30.9	26.1	33.3	0.541
Asthenopia	29.4	13.0	37.8	0.034

Totals exceed 100% as participants gave more than one symptom; values in **bold** are significant, $p<0.05$.

5.4.4 Experienced symptoms at time of examination vs OSDI score

Analysis of the relationship between the experienced symptoms at the time of the examination and the OSDI Group (Table 5-3) showed that ‘tired eyes’ ($p=0.01$), ‘burning eyes’ ($p=0.01$), ‘stinging’ ($p=0.036$) and ‘asthenopia’ ($p=0.002$) were more frequently experienced in OSDI Group II. All other symptoms showed no statistical difference between the two OSDI groups (dry eye, $p=0.67$; itching eyes, $p=0.92$; blurry vision, $p=0.956$; irritation, $p=0.145$).

Table 5-3 OSDI score per gender and OSDI Group I and II.

OSDI	Normal	Mild	Moderate	Severe
Male	6	12	3	2
Female	8	8	12	17
OSDI I	N=34			
OSDI II			N=34	

5.4.5 Experienced symptoms at time of examination vs clinical signs

Of all the experienced symptoms, only ‘dry eye’ had a weak, negative correlation with MGD, with a higher MGD score associated with symptoms. A higher LWE superior and inferior score was correlated with symptoms of ‘blurry vision’. TBUT had a weak, positive correlation, with an absence of ‘burning sensation’ and ‘asthenopia’ linked to a higher TBUT. An absence of ‘dry eye symptoms’ with corneal staining showed a weak correlation.

Table 5-4 Correlation between experienced eye symptoms at examination and clinical tests and signs.

	MGD	Corneal staining	TBUT	LWE Sup	LWE Inf
Dry eye symptoms	-0.252	0.249			
Burning			0.261		
Asthenopia			0.204		
Blurry vision				-0.358	-0.294

Correlations in **bold** are significant, $p < 0.05$

5.4.6 OSDI score

The OSDI score was significant higher for females ($p=0.005$). No statistically significant difference was found in the number of working hours per week and OSDI score ($p= 0.165$). A correlation was found between OSDI group and social impact, ($r=0.363$, $p<0.003$), with the OSDI Group II (moderate-severe) experiencing more social impact.

5.4.7 Clinical outcome on tear film, and eye and adnexa

For over 60% of the all participants, the TBUT test and PRT outcome results were marginal (5-10 secs and 10-19 mm, respectively) (Figure 5-2). Over 30% of the participants had a TBUT of less than 5 secs (Category: Dry), and over 15% had a PRT of less than 10mm (Category: Dry) (Figure 5-2). Nearly 30% had some form of corneal staining, nearly 70% had lissamine green staining, and nearly 55% had fluorescein staining of the conjunctiva. Comparison of the OSDI I and II groups found that the “dry” score for the OSDI I group for TBUT and PRT was less than the OSDI II group, although the OSDI I group had a higher percentage of marginal outcome for TBUT and PRT.

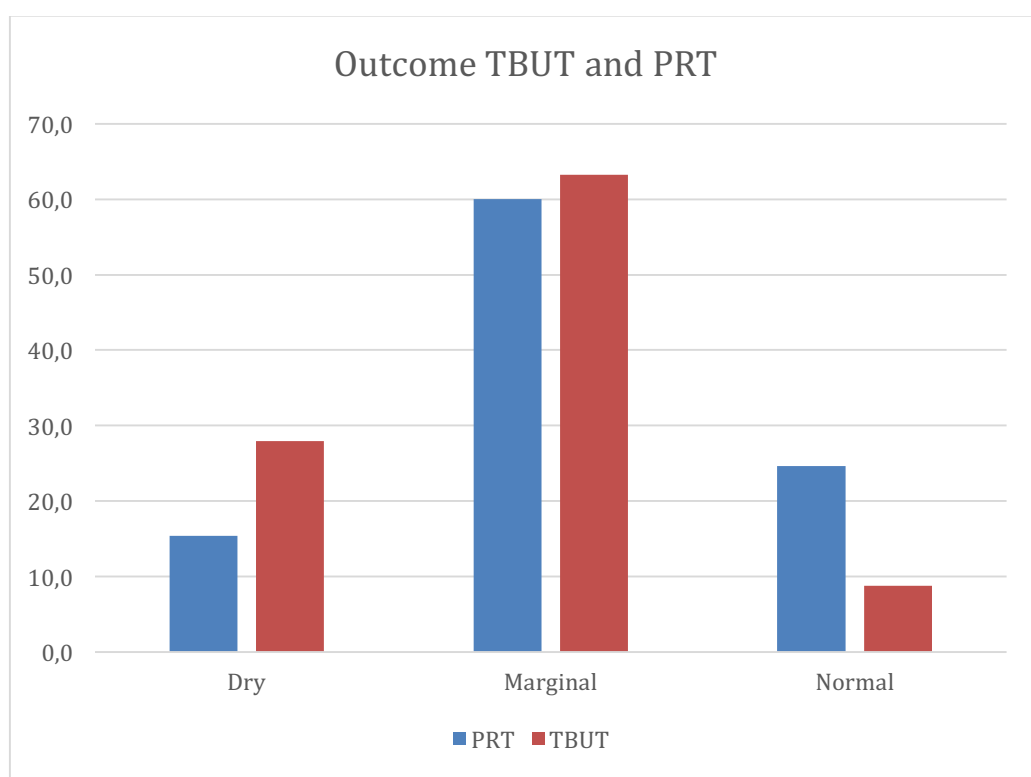


Figure 5-2 Outcome of TBUT and PRT test worst eye.

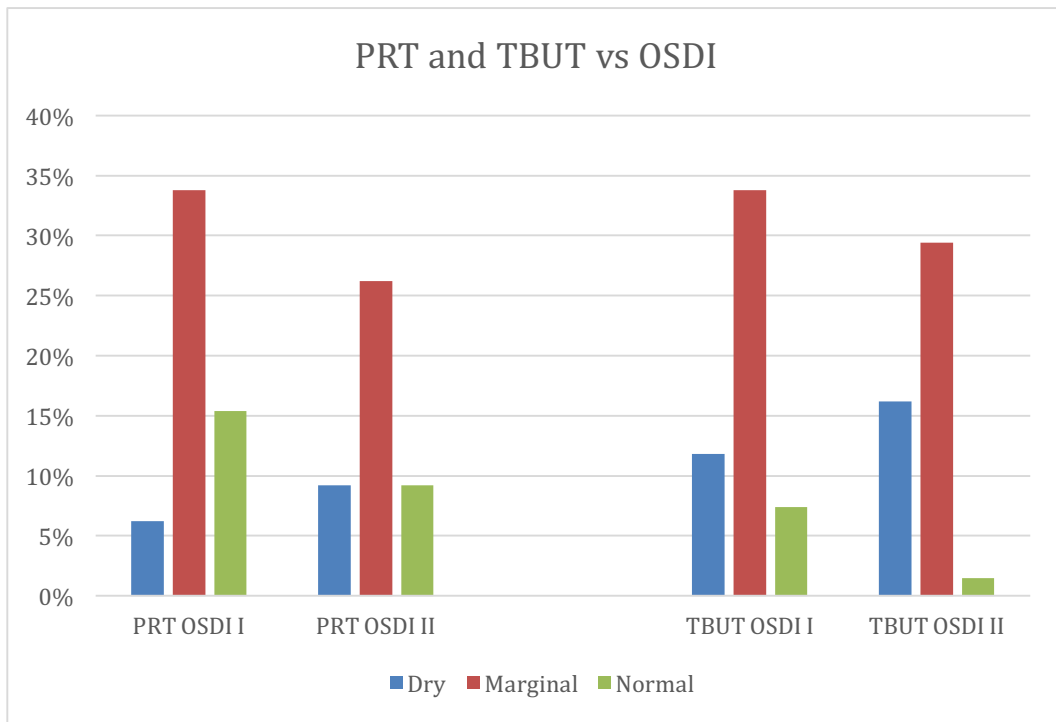


Figure 5-3 OSDI group PRT and TBUT worst eye.

5.4.8 Correlation between clinical tests and clinical signs

MGD showed a statistically significant, moderately negative, correlation with TBUT ($r=-0.507$), meaning that a lower TBUT correlated with a more severe grade of MGD. The TBUT showed a significant, but weak, correlation with conjunctival fluorescein staining ($r=-0.266$) (Table 5-6).

Significant, but moderate, correlations were found between corneal and conjunctival fluorescein staining ($r=0.404$), and between fluorescein and lissamine green staining of the conjunctiva ($r=0.526$). LWE superior showed a strong correlation with LWE inferior ($r=0.862$), whilst LWE superior and inferior both had weak correlations with PRT ($r=0.271$, $r=0.306$).

Correcting for age and gender did not change the statistical significance ($p<0.01$) of the moderate, negative correlation between MGD and TBUT, or between fluorescein staining of conjunctiva and cornea, or between fluorescein staining and lissamine green staining of the conjunctiva.

Table 5-5 Correlation clinical tests and signs.

	PRT	TBUT	Anterior Blepharitis	MGD	Corneal staining FL	Conjunctival staining FL	Conjunctival staining LG	LWE Sup	LWE Inf
PRT		-0.032	0.048	0.195	-0.079	-0.127	-0.169	0.275	0.306
TBUT	-0.032		0.197	-0.507*	-0.103	-0.266	-0.146	-0.077	-0.086
Anterior Blepharitis	0.048	0.197		0.027	0.015	0.145	0.189	0.052	0.133
MGD	0.195	-0.507	0.027		-0.004	-0.131	-0.094	0.153	0.228
Corneal staining FL	-0.079	-0.103	0.015	-0.004		0.404*	0.142	-0.015	-0.017
Conjunctival staining FL	-0.127	-0.266	0.145	-0.131	0.404*		0.526*	-0.019	-0.005
Conjunctival staining LG	-0.169	-0.146	0.189	-0.094	0.142	0.526*		0.093	0.057
LWE Sup	0.275	-0.077	0.052	0.153	-0.015	-0.019	0.093		0.862*
LWE Inf	0.306	-0.086	0.133	0.228	-0.017	-0.005	0.057	0.862*	

Values in **bold** are significant, $p < 0.05$. * Correlation is significant at 0.01 level; PRT: phenol red thread test, TBUT: tear break-up time, MGD: meibomian gland dysfunction, FL: fluorescein, LG: lissamine green, LWE: lid wiper epitheliopathy

5.4.9 Clinical outcome and referrals

The top 5 reasons for onward referral were: MGD (over 45% of participants had an MGD grade of 2 or higher), uncorrected refractive error (nearly 30%, allergy-related (20%), blepharitis (19%), and “glaucoma” suspect (18%), contact lens-related dry eye accounted for 11% of referrals (Figure 5-4).

The eye care professional consulted most often was the optician ($n = 35$), and a high proportion had seen an eye care professional in previous 2 years ($n = 50$) (Table 5.6).

In the Netherlands, optometrists primarily work in an optical store, as the eye-care professional in primary healthcare. This could mean that participants falsely believe they were seen by an optician, but, in the Netherlands, the refractive optician is not educated for pathology and dry eye treatment.

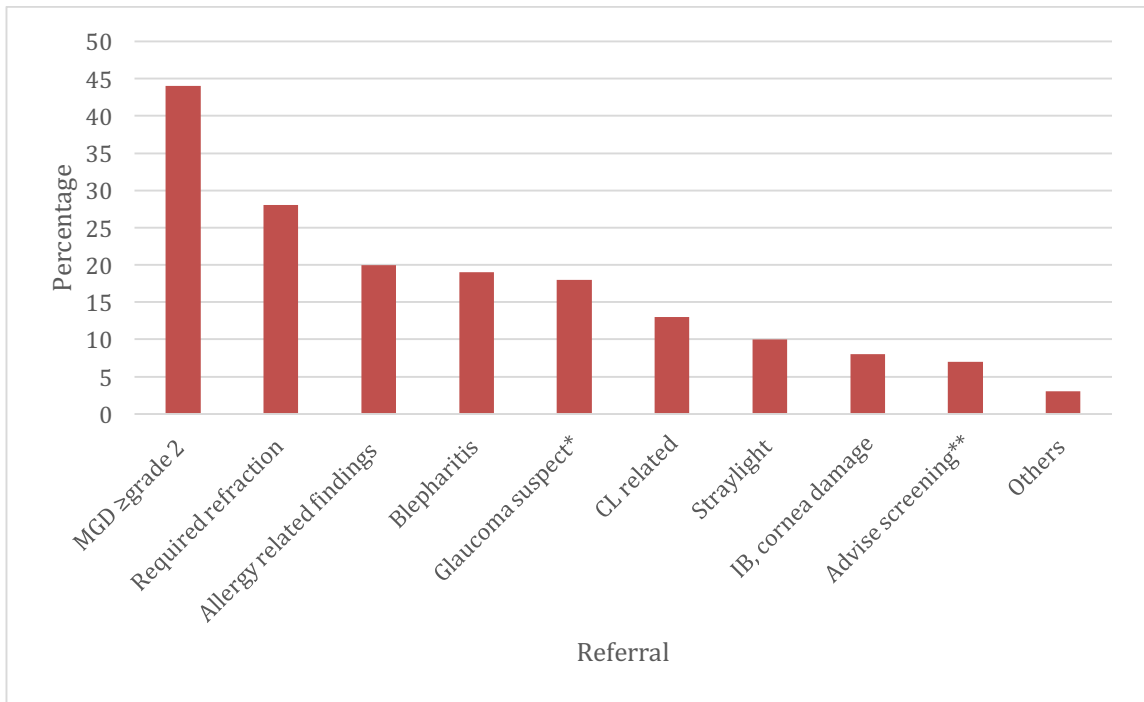


Figure 5-4 Reasons for referral.

Meibomian Gland Dysfunction (MGD): ≥Grade 2; CL-related (contact lens) dry eye: discomfort and dry eye symptoms while wearing lenses reporting less symptoms without lenses; IB (Incomplete Blinking or possible incomplete closure of the eye during the night with inferior cornea damage); Glaucoma suspect: narrow anterior chamber, Van Herick Grade II, Krukenberg Spindle; Advise screening: retinal screening, high myopia, light flashes, family history. Total exceeds 100% as participants had more than one reason for referral.

Table 5-6 Comparison between OSDI Group for eye exam details.

	OSDI Group I (n)	OSDI Group II (n)
Last eye exam		
Less 1 year	7	9
1-2 years	16	18
3-5 years	1	2
6-10 years	0	0
10 years and up	1	3
Never had	9	2
Who performed the eye exam?		
Optician	17	18
Contact lens specialist	4	3
Optometrist	1	0
Ophthalmologist	4	9

Never had an exam	5	2
Not known	5	0
Referrals		
Optician	1	0
Optometrist	30	30
GP	2	3
ARBO	1	1
NONE	4	2

5.5 Discussion

This study was performed in a modern office-building that was described as having an acceptable indoor climate by the NEN 7730:2005 guidelines (Nederlandse Norm). Whilst the employees were generally healthy, a large proportion reported ocular symptoms during their working day. When asked, half complained of tired eyes, and almost a third experienced some DED symptoms and ocular irritation. de Kluizenaar et al. (2016) reported 34% self-reported dry eye symptoms, with office workers surveyed reporting DED symptoms in the 4 weeks prior to assessment, with less complaints at home. Their study also had a slightly lower mean age and a bigger age range than in this study.³⁴ Study 2 also found that the symptoms experienced in the office environment, such as 'dry eye', 'itching', and 'burning sensation of the eyes', were more commonly experienced at work than at home. Females experienced more symptoms than the male participants, with the OSDI showing a statistically significant higher score for women than men, indicating that more severe DED was seen in women. No specific age differences in OSDI score or in objective test outcome were found

Subjective symptoms of dry eye symptoms can be triggered by intense, visually-demanding tasks, such as working on a computer or laptop.^{36,47,49,157} Computer-use, which is known to cause a reduced blink-rate and more incomplete blinks than reading from printed paper, plays a significant role in computer vision syndrome.^{36,47} Yokoi et al.^{37,53} focused on the intense use of visual display terminals (VDT), rather than the office environment, but still found that 4 hours of computer work increased the risk of DED. Thorud et al.⁵⁶ found

that watery, tearing eyes, blurred vision and tiredness were the three single complaints that significantly increased during the working day. They found that even after 1 hour of intensive computer work, a patient might experience a significant increase in tiredness and pain in and around the eyes, along with itchiness, gritty eyes, blurred vision and photophobia, which are symptomatic of DED. The reduced blink-rate can cause an unstable lipid layer by interfering with the secretion of lipids from the meibomian glands, which accelerates tear evaporation.³⁶

The low TBUT and low PRT found in this investigation is alongside the published finding that tear film instability is produced in low relative humidity indoor air,^{35,147} leading to increased ocular pain sensation.¹⁷¹

The combination of high-cognitive-demand tasks, low environmental humidity, reduced tear secretion, and a higher indoor temperature, is seen as the most important issue for developing dry eye in an office environment.¹⁷² The workers in this study were working in an office building with a paperless office strategy, focusing on the use of computers and laptops. Screen-use for more than 6 hours per day is linked to a reduced sleep quality (less hours and more broken nights),¹⁷³ and sleep deprivation is also associated with dry eye symptoms.¹⁷⁴

Lee et al. (2014)¹⁷⁴ found a higher tear film osmolarity level, a shorter BUT, a lower Schirmer score, and a higher pain score in the morning, for a healthy subject who did not sleep for 24 hours, compared to a control group with 8 hours sleep, and concluded that sleep deprivation could exacerbate DED signs and symptoms. Thus, an initial positive treatment would be to encourage workers to get a good night's sleep.

Diurnal variations have been described and evaluated across normal populations for many human physiological processes. These physiological diurnal variations can vary during the day, with ocular symptoms of irritation and pain more significantly evoked towards the evening.¹⁷⁵ Corneal sensitivity may be higher if provoked during the day by any sub-clinical inflammation affecting the corneal nerves, possibly leading to hyperesthesia. The relation between

hyper-osmolarity and tear instability seems to result in corneal inflammation and stimulation of the sensory neurons.⁶⁸

This hypothesis appears to be supported by the study of Kaido et al. (2016),⁶⁸ in which subjects with a decreased BUT and dry eye symptoms showed a significantly higher corneal sensitivity for blinking and pain than subjects who had a low BUT, but no symptoms. Kaido et al. suggested that prophylactic treatment could be recommended to reduce damage to the sensory nerves.⁶⁸ This prophylactic treatment could take the form of using artificial tears protecting the cornea from episodes of hyper-osmolarity.

Furthermore, the increase in tear osmolarity that can occur from increased tear evaporation, along with any chronic lid disease, could influence the development of meibomian gland dysfunction (MGD).¹⁷⁶ In this investigation, a correlation between a lower TBUT and a higher MGD score was found (albeit moderate), even when adjusted for age and gender. Also, the symptom of 'dry eye' felt at the beginning of the examination, also had a significant, but weak, correlation with MGD. This reveals that there is a link between the workers' symptoms and their clinical signs.

Indeed, the diagnosed meibomian gland dysfunction (MGD) was relatively high overall. In total, 85% of participants had some form of MGD, and 45% of participants were referred for follow-up and treatment. This finding also compares with Fenga et al.(2008) who reported on a clinical study of 70 VDT users and found that over 74% had MGD.¹⁷⁷ In contrast, Viso et al (2011)¹⁷⁸ found only 33% of participants (40-96 years of age) (n=619) could be diagnosed with MGD, the diagnosis was based on assessment, with the evidence of MGD based on digital expression and assessment of the eyelid margins. Also, the participants were not working primarily in an office environment and the mean age was higher than in this investigation.

The mechanism for development of MGD is not clearly understood, but if the force from the blinking mechanism on the glands is needed to express the

meibum secretion, then this could be jeopardised by a reduced blink-rate or by fewer full blinks during highly-visually demanding tasks.^{26,73} Grading of the LWE superior and inferior showed a significant, but weak, correlation with blurry vision and a lower PRT. The adoption of blink-rate assessment and LWE as standard tests in the optometric routine could create better understanding in the progression and development of MGD. However, the early sign of a changed lid margin, as a marker for the development of MGD, is not the same as the lid wiper epitheliopathy (LWE) investigated in this study, but Bron et al. (2011) suggested that progressive damage to the lid margin (represented by Marx's line) could play an important role in the development of MGD, and that the damage seen could be described as part of LWE.¹⁷⁶ It is important to note that symptoms-based diagnosis can fail to diagnose asymptomatic MGD.

The combination of high-cognitive-demand tasks, low environmental humidity, reduced tear secretion, and a higher indoor temperature, is seen as the most important issue for developing dry eye in an office environment.¹⁷² The workers in this study were working in an office building with a paperless office strategy, focusing on the use of computers and laptops. Screen-use for more than 6 hours per day is linked to a reduced sleep quality (less hours and more broken nights),¹⁷³ and sleep deprivation is also associated with dry eye symptoms.¹⁷⁴

Modern office-building environments are known for having low humidity, and the participants in Study 2 blamed low humidity as a reason for developing dry eye.¹⁵² Alex et al. (2013)¹⁷⁹ showed, in an experimental setting, that low humidity exposure increased corneal and conjunctival fluorescein staining significantly in all participants, whether they had healthy eyes or dry eyes. The mechanism for this appears to be that low humidity encourages tear evaporation, which may be exacerbated by a reduced blink-rate. Thus, a treatment for this is to improve office humidity, if possible, or to promote better blinking during computer-use.²⁶

More generally, dehydration in office environments could play a role in the development of dry eye symptoms.¹⁷¹ An investigation comparing the urine of employees working in extremely low relative humidity found a higher percentage of employees with dehydration,¹⁸⁰ and a pilot study by Caroline et

al. (2011)⁵, amongst students, showed a trend toward resolving dry eye symptoms with a controlled intake of water for 2 weeks. The clinical implication is that a patient's therapy could be individualised, preventing the development of signs and symptoms during the day from high tear-film osmolarity levels triggering the corneal nerves to respond. The use of a questionnaire, as described by Brasche et al. (2001),¹³⁹ correlated well with the medical tests used to examine SBS (Sick Building Syndrome) symptoms, such as dehydration of the skin, and they found that 'low sebum content and correlated with 'rough skin' and 'dry skin'. They also recommended a treatment of drinking more water during the day.

The impact of dry eye symptoms on daily activities at work should not be underestimated by the employer, the eye-care professional or the OHP. The prevention of work-related dry eye, and its potential evolution in DED, should be a co-ordinated response by employees, employer, services in the area of occupational health and safety, OHPs, optometrists and GPs. Facilitating screening of eye-related symptoms in an office environment could be beneficial to help promote ocular comfort.

5.5.1 Limitations

The small number of participants seen by the investigator is a limitation. This explorative "in-office" investigation was undertaken in an office environment with a long-term history of subjective employee complaints about the indoor air quality, and a rich history of internal investigations of the quality of indoor air. However, participants may have been hesitant to judge their own workplace, and indirectly their employer. This could strongly influence the participants approach of how they cooperate with this investigation. An individual's subjective complaints might also be such a strong influence on their daily activities at work that volunteering would be logical. On the other hand, after years of symptoms, there could be an amount of resignation or fatigue to their

⁵ *Caroline PJ.Andre MP, Water Intake and Dry Eye Contact Lens Spectrum Volume: 26 Issue 7*

current situation and a reluctance to participate. Even with the general invitation to participate for an eye examination, the above situated issues could influence and bias the population.

Subjective dry eye symptoms can be triggered by intense, visually-demanding tasks, such as working behind a computer or laptop,^{36,47,49} but the OSDI only asks about dry eye symptoms and disturbance over the previous 7 days. This is unlikely to be specific enough for work-related dry eye, as the environmental conditions can fluctuate during the day and enhance any eye irritation. Maybe, in an office environment, the use of a comfort index might be of more interest for assessing the impact on patient well-being and the level of irritation.¹⁸¹

There was a challenge in scheduling subject appointments, since the investigation was run during a particularly busy time in the office, with the implementation of new systems after a big change in the law. Consequently, after Visit 1, quite a few participants were unable to schedule a new appointment, or had changed positions, or had left this specific building. The investigator was not able to anticipate these issues when planning the study.

The environmental influence, and the effect of highly visually demanding tasks during the day on tear film characteristics, were combined in this study, but dry eye symptoms can also be influenced for each individual by any ocular pathology present. Symptoms can be exacerbated by underlying factors such as an incorrect prescription, MGD, blepharitis or allergy, and, in this study, the onward referrals for blepharitis, MGD and allergic conjunctivitis were high.

The possible relationship with indoor air quality needs to be addressed. Air pollution in office buildings is known to irritate the mucous layer of the nose, skin and eyes, and dust exposure correlates with eye irritation and dry eyes.^{43,182} Malerbi et al. (2012)⁴⁰ found a significant correlation between outside air pollution and clinical diagnosed blepharitis, and blepharitis is an ocular pathology that de-stabilises the tear-film and indirectly causes dry eye symptoms. Treatment of blepharitis and prevention of the development of blepharitis can be successful.^{40,183}

5.6 Conclusion

The ambient work environment can be crucial in moderating the risk factors for development of dry eye symptoms during the working day. Low humidity and computer work have a negative influence on the development of dry eye symptoms. Long-duration computer work can influence sleep quality, which could play a role in development of dry eye and higher pain corneal sensation in the morning. The exposure to dust or air pollution can play a role in the development of blepharitis and allergic conjunctivitis.

In this investigation, the relationship between the work environment and the high rate of ocular pathology, such as MGD and blepharitis, indicates the need for further investigation into the possible relationships between low humidity, dehydration and computer work in office workers, low BUT, the outcome of any prophylactic treatment, the prevention of dehydration in office workers during the working day, and possible eye symptoms. Any objective investigation would need to distinguish between the signs and symptoms of eyestrain and dry eye-like symptoms, and real tear film instability and DED.

In the Netherlands, both the employer and employee have responsibility for occupational health and safety policy under agreed, working conditions. The current multi-disciplinary guidelines for office health and safety focus primarily on vision and the VA requirements for computer work, including advice on computer glasses. This results from this study suggest that the investigation of ocular health should be part of this agreement, in order to prevent or limit the development of dry eye in workers.

5.7 Next step

Although, no direct relation was found between the combination of the indoor environment and the ocular pathology, this study has confirmed the previous published studies which indicate that office workers with dry eye symptoms can have underlying ocular pathology. The question then becomes, how can this be managed effectively for the worker?

The GP, optometrist and OHP are all involved, in different ways, in the diagnosis and treatment pathway. For successful prevention and treatment, it is therefore important to consider how primary healthcare can focus on inter-professional, patient-centred care, with focuses on prevention, functioning and participation in the office environment.

The first step is to better understand the current DED diagnosis and management in primary healthcare between the two principal eye healthcare professionals: the GP and the optometrist.

6 Agreement in dry eye disease care management between General Practitioners (GPs) and Optometrists in the Netherlands

6.1 Introduction

In order to appreciate the factors involved in dry eye disease (DED) management in primary healthcare in the Netherlands, it is useful to know the opinions of the key professionals involved: General Practitioners (GPs) and Optometrists. In particular, information on treatment options, co-management of the dry eye patient in primary care, and the proportion of ophthalmological referrals, will help direct further studies that investigate the types of dry eye reported by GPs and optometrists, and the diagnostic methods involved. The findings from this research on primary care and dry eye investigation will lead towards better care management options for DED patients.

The healthcare system in the Netherlands relies on the triage of patients within the primary healthcare level, especially by the GP for treatment and referral. The GP is the gatekeeper to secondary healthcare.¹⁸⁴ In the Netherlands, optometrists also have a role as a gatekeeper for referral to ophthalmology. However, difficulties arise in the definition used in primary care for DED, and no distinct criteria are available across primary healthcare in the Netherlands. This problem of definition used and diagnostic tests applied is investigated in several studies elsewhere, and all describe wide variations among eye care practitioners and their scope of practice.¹⁸⁵

DED is a multi-factorial, chronic, ocular disease, with significant impact on visual functioning and daily life. This highly symptomatic, chronic condition is experienced by patients in a variety of symptoms that range from ocular discomfort to pain, from an impaired visual performance to photophobia, and so careful questioning is important for good diagnosis.^{120,186-188} The multi-factorial nature of DED makes it difficult to define in one symptom or by any single current investigative technique, and, most importantly, no single treatment

works for all. Moreover, because of the multi-factorial origin of the disease, patient-reported symptoms and diagnostic tests have poor correlation.^{12,16,65,102}

Data collected from a survey undertaken by the Optometrie Vereniging Nederland (OVN) (about the tasks and duties in diagnosing and treating red eye and tear film/DED in primary care) showed a strong opinion by ophthalmologists for letting the GP take charge in the investigation, diagnosis and treatment, rather than the optometrist.¹¹⁹ However, this opinion was made without having a good overview of the impact of DED in primary care, and the knowledge, equipment and skills of the optometrist in managing DED. It could be argued that, with the multi-factorial and chronic nature of DED, and the possible environmental influences, the optometrist should be the first practitioner in the line of care.

In the literature, to our knowledge, there are no reports comparing the diagnosis and management of DED between GPs and optometrists. In contrast, the literature shows a generally good agreement in diagnosis and management between ophthalmologists and optometrists who have similar levels of education.^{120,189}

6.2 Aim

The aim of this study was to investigate and determine the agreement between optometrists and GPs in relation to the causes of developing DED, DED symptoms, investigative techniques, and treatment options used.

6.3 Methods

Using a cross-sectional design, a web-based questionnaire was developed to survey knowledge, investigative methods and therapy preference for patients with DED, using forced-choice questions and Likert scales.

6.3.1 Survey Design

An initial survey was designed, and a pilot study of 14 questions was sent by email to 12 optometrists and 12 GPs who had some involvement in local initiatives for co-management, and had access to the internet. The questionnaire was hosted on the surveymonkey.com website, with password-restricted access to the data. The access time for completing the survey was 1 month and one reminder was sent after 2 weeks. Eleven optometrists and five GPs completed the pilot survey. The responses from these participants were not included in the main study. With feedback from this pilot study, a final version of the questionnaire was developed, consisting of 10 questions (Table 6.1). The survey was designed in English, and translated into Dutch when used.

6.3.2 Recruitment

Optometrists: An invitation email, with details of the internet link to the survey, was sent to all optometrists registered with the OVN (n=870). Access to the survey was permitted from November 2012 to March 2013. In the invitation, participants were asked to fill in the survey if they were working mainly in primary healthcare, since the scope of practice for an optometrist working in secondary (in ophthalmology offices) or tertiary healthcare (low vision or therapeutic lenses) will be different if they are working in direct consultation with an ophthalmologist, and have access to therapeutics (directly or indirectly) prescribed by ophthalmologist. The patients they see may also differ in severity and co-morbidity of eye diseases to those more commonly seen in primary care practice.

GPs: Paper copies of the survey, along with details of the internet link to the survey and an invitation to participate in the study, were sent by general mail to the 224 offices of the HAP (HuisArtsen Post) in the Netherlands. HAP is the main out-of-hours GP Service in the Netherlands. The survey was sent between November 2012 and January 2013. A direct email invitation, with details of the internet link, was also sent to 1471 email addresses collected from an open-access internet site for internship placements for GPs. The GPs were selected

from each province of the Netherlands working in primary healthcare, and the email invitation was sent from February 2013 to July 2013.

Table 6-1 Survey questions investigating knowledge, investigative methods, therapy preference and experience of GPs and optometrists.

Questions 1 and 2 asked for estimates of patients seen:
1. <i>How many patients do you see per week and how many dry eye patients do you see per week?</i>
2. <i>Can you give an estimation of the average age of patients in your practice with dry eye problems, divided according to those not wearing contact lenses and those wearing soft contact lenses?</i>
Question 3 asked for the use of specific dry eye questionnaires and was answered from 3 choices: OSDI, McMonnies, and personally designed dry eye questionnaire.
3. <i>To aid diagnostics, do you use a dry eye questionnaire?</i>
The following questions were forced-choice:
Question 4 was answered by Likert scales with five choices; not specific, sporadically, occasionally, most frequently, always
4. <i>Which of the following symptoms do you specifically associate with dry eye?</i>
Questions 5 to 8 were answered by Likert scales with five choices: never, sporadically, occasionally, most frequently, always
5. <i>Which of the following possible causes of dry eye do you see in your practice?</i>
6. <i>Which of the following investigative techniques do you use to diagnose dry eye?</i>
7. <i>Which of the following is the reason of development of dry eye in your patients?</i>
8. <i>What is the most commonly used/prescribed treatment after your diagnosis of dry eye?</i>
Question 9 was answered by forced-choice on a Likert scale with three choices: No, I do not know these investigations, Yes, but never read it in detail, Yes, have read some or have detailed knowledge of the articles.
9. <i>Are you aware of the most recent large scale research reports of dry eye, such as the Dry Eye Workshop (DEWS) or Meibomian Gland Disease (MGD) workshop reports?</i>
Question 10 was answered by forced choice, yes or no
10. <i>Are you working together with an optometrist or GP (co-management) in your area specifically for dry eye management?</i>

6.3.3 Ethical approval

For ethical approval, each English version of the survey questionnaire was translated into Dutch and screened by a native English-speaking Dutch optometrist and colleague at the Hogeschool Utrecht, and then translated back to English. Only the final questionnaire was sent to the Ethics Committee. The study was approved by the Human Research Ethics Audit Committee of the School of Optometry and Vision Sciences at Cardiff University and was

consistent with the tenets of the Declaration of Helsinki. Access to the survey was secured using a login code and password. Only the researcher had access to the data. The data was stored on an online database, and was converted directly to text format for analysis using the SPSS 12.1 (IBM, USA) statistical analysis software program.

6.3.4 Statistical methods and analysis variables

Cronbach's alpha, a coefficient of consistency, was used to measure internal consistency of the questions per group. Descriptive statistics were used to describe the demographic data for the first two survey questions using median, means and standard deviations. A Pearson's Chi-square test was used to compare differences in given answers among the GPs and optometrists. A p-value of <0.05 was considered to denote statistical significance. Frequency tables were constructed for both GPs and optometrists for each question to provide an overview of the responses given. The Kendall W test (or Kendall's coefficient of concordance for ranks) was used to value the agreement amongst GPs and optometrists, with 0 indicating 'no agreement' and 1 indicating 'complete agreement'.

6.4 Results

Optometrists: Of the 861 emails sent by the OVN, 25 were returned with a wrong or not usable email address, or from a full inbox. In total, 836 optometrists were reached by email. Of the 836 optometrists reached, 138 responded, giving a response rate of 16.3%.

GPs: Of the 1471 GP email addresses, 81 rejected the email and 59 emails bounced. In total, 1331 GPs were reached by email and of those a total of 93 GPs completed the survey, to give a response rate of 7%. Of the 93 completed surveys, 77 GPs used the direct access link to the survey, 14 responded indirectly by going online to the survey website, and 2 sent a completed print version by regular post.

The survey results for each subject cohort showed good internal consistency, with a Cronbach alpha coefficient of 0.833 for the GPs and 0.885 for the optometrists.

6.4.1 Patient numbers

A comparison of the median number of general patients seen per week by optometrists and GPs shows that the number for the GPs is almost double that for the optometrists: the median patients seen per week by the GPs was 105 and by the optometrists was nearly 42 (41.97). However, while the estimated number of dry eye patients seen per week was approximately 2 (1.78) patients for the GPs, it was almost 14 patients for the optometrists (Table 6.2).

The estimated average age of dry eye patients seen without soft contact lens (CL) wear was significantly different between the GPs (nearly 61 years) and the optometrists (nearly 56 years) ($p=0.011$), although still of a similar age. Likewise, the average age of the patients with dry eyes and wearing soft CL was significantly different, with GPs at almost 39 (38.57) years and optometrists at 40 years ($p=0.03$), but this is not clinically significant (Table 6.2).

6.4.2 Use of Dry Eye Questionnaire

Analysing this question with the Pearson chi-square showed no statistical significant difference between optometrists and GPs for the use of either the OSDI ($p=0.147$) or McMonnies ($p=0.403$) questionnaires. Both professions did not use the questionnaires much, the optometrists are using a personalized dry eye questionnaire the most 62 positive response of the 132 (Figure 6-1) as 10 of the 87 GPs'.

The other questionnaires were almost not used by both professionals (Figure 6-1). A significant difference was found for the use of a personalised questionnaire ($p<0.01$), with the optometrist more frequently using personalised questionnaires.

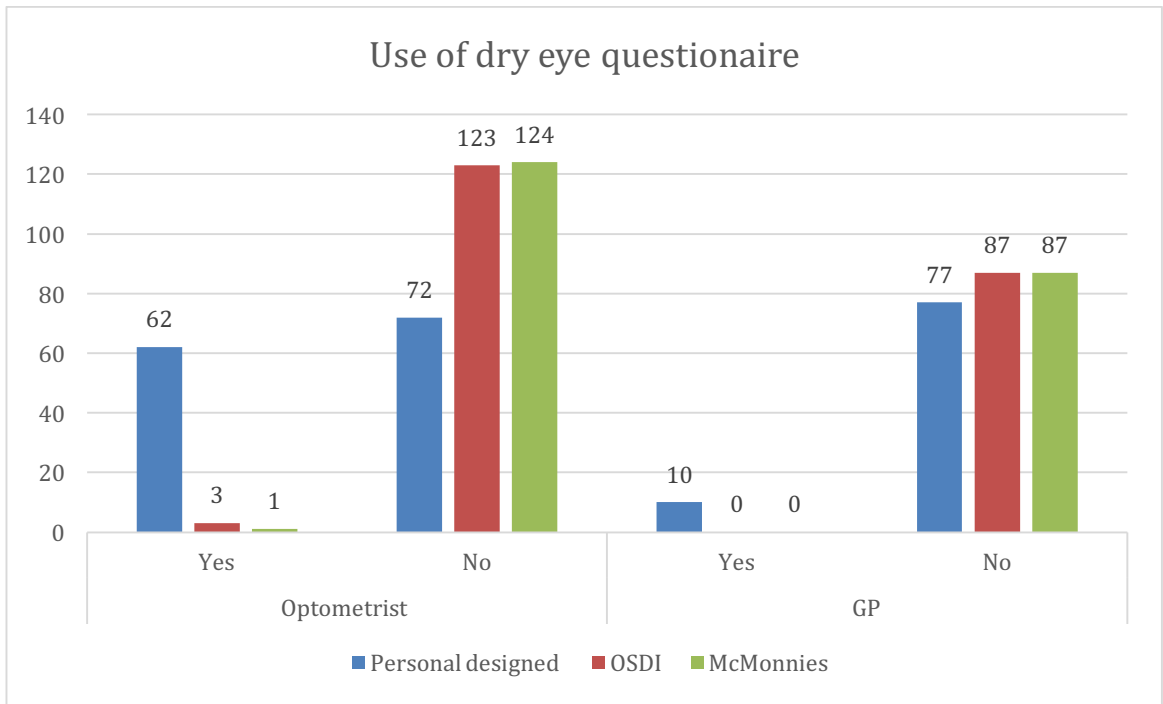


Figure 6-1 The use of dry eye questionnaires by optometrists and GPs’.

Table 6-2 Demographic data of patients seen per week .

	Median number of patients seen per week	Average number of dry eye patients seen per week	Average age of dry eye patients not wearing soft contact lenses	Average age of dry eye patients wearing soft contact lenses
GPs	n=87	n=86	n=71	n=45
	105 patients	1.78 patients sd=1.77	61.41 years sd=9.5	38.57 years sd=10.5
Optometrists	n=136	n=110	n=88	n=85
	41.97 patients	13.94 patients sd=11.85	55.9 years sd=9.47	40 years sd=7.79
P value	P<0.001	P<0.001	P=0.03	P=0.011

(n = number of participants completing the question)

6.4.3 Symptoms for dry eye

A statistically significant difference ($p < 0.0001$) was found between optometrists and GPs in judging which patient symptoms they specifically associated with dry eye, for: ‘itching of the eye’, ‘transient vision changes’, ‘sticky eyelids in the morning’, ‘pain sensation in the eye’, ‘pain around the eye’, ‘photophobia’,

'eyelid hyperaemia', 'bulbar conjunctival hyperaemia', 'skin disease (e.g. acne rosacea)', and 'asthenopia'. For these symptoms, GPs were less likely to link them with dry eye. However, for 'burning sensation of the eye' and 'irritation of the eye' ($p=0.073$ and $p=0.298$, respectively), there was closer agreement for both practitioners that these symptoms are an indication for dry eye.

Using Kendall's W coefficient to assess the consistency of agreement within the optometrists across the symptoms, a coefficient of 0.291 was found, indicating only a small level of agreement. A similarly low coefficient of 0.390 was found for the results of the GPs.

The mean rank of all symptoms showed that 'burning sensation of the eye', 'irritation of the eye' and 'tearing of the eye' were ranked highest by the GPs, while for the optometrist the mean ranked top three were: 'burning sensation', 'tearing of the eye' and 'irritation of the eye'. The frequency tables for the survey answers are given graphically in Figures 6.1 and 6.2.

Dry eye symptoms indicated by optometrists

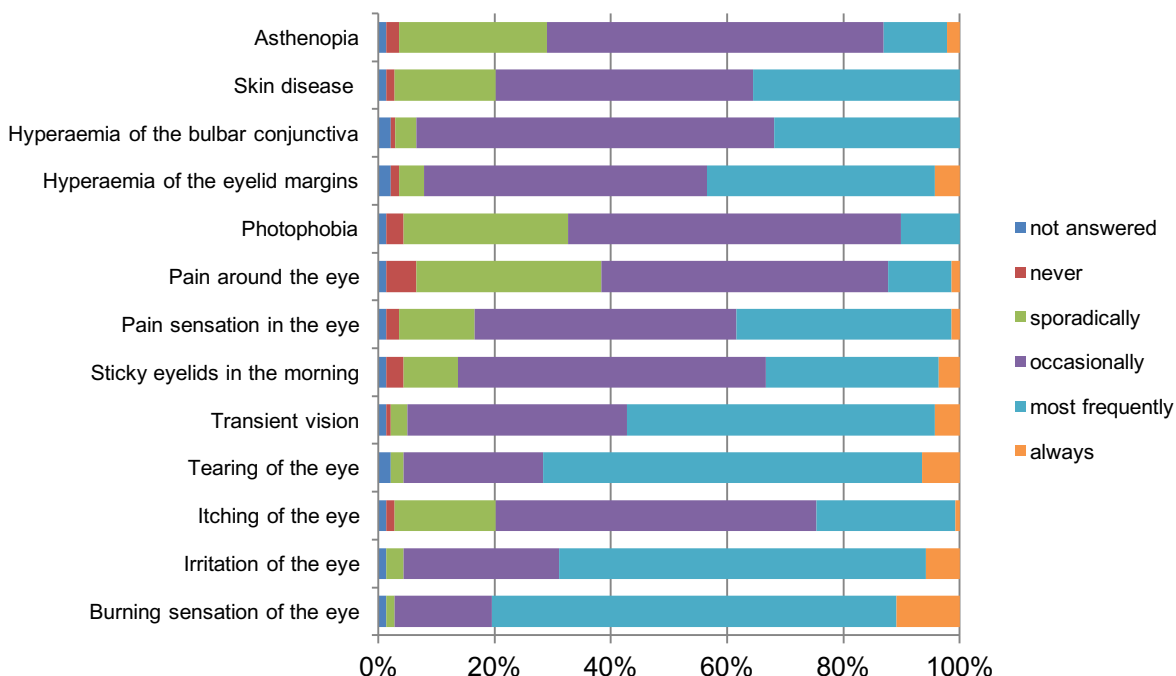


Figure 6-2 Percentage agreement for dry eye symptoms indicated by optometrists.

Dry eye symptoms indicated by GPs

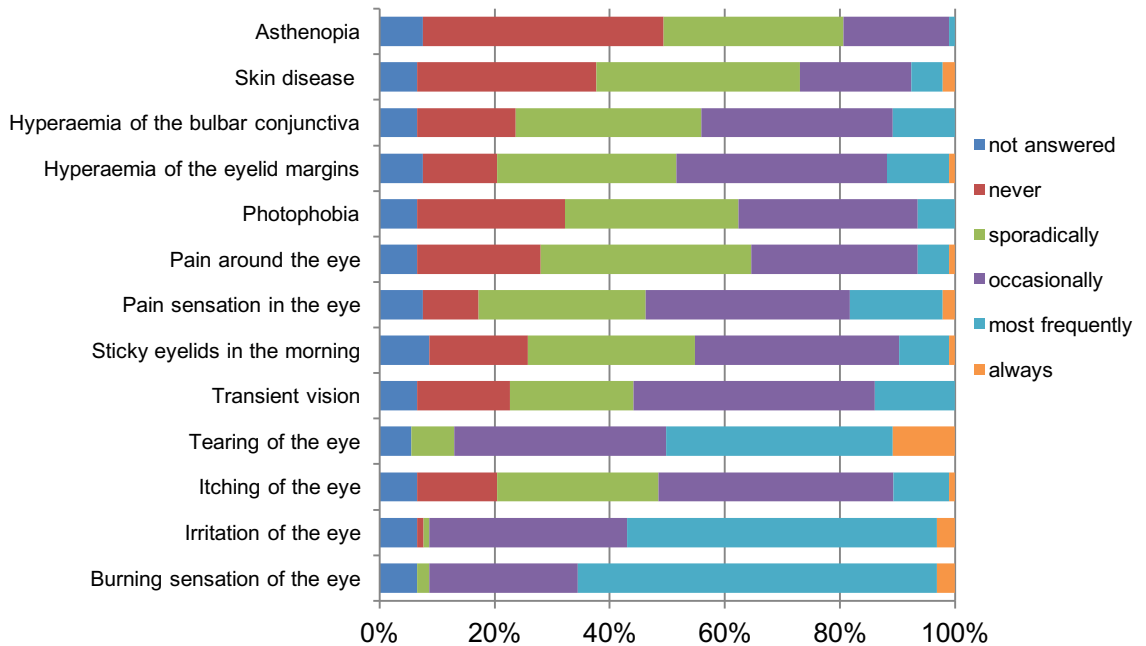


Figure 6-3 Percentage agreement for dry eye symptoms indicated by GPs.

6.4.4 Causes of dry eye disease

Of the possible causes for dry eye in patients attending their practice, no significant difference was found between GPs and optometrists when diagnosing dry eye as an ‘age-related disease’. For all other possible causes: ‘medication use’ ($p < 0.001$), ‘auto-immune’ ($p < 0.004$), ‘allergy-related’ ($p < 0.0001$), ‘inflammation’ ($p < 0.0001$), ‘work-related’ ($p < 0.0001$), ‘contact lens use-related’ ($p < 0.0001$), and ‘hormonal-related’ ($p < 0.0001$), there was a statistically significant lack of agreement between the optometrists and GPs. In general, the optometrists showed more variance in describing the causes of dry eye.

Optometrists indicated ‘work-related’ (highest score), ‘age-related’ and ‘hormonal-related’ causes as the main reasons for developing dry eye. The highest mean ranking for the GPs was ‘age-related’, then ‘work-related’ and ‘contact lens use’. The Kendall W coefficient shows some concordance (0.311) for optometrists, with GPs showing a slightly lower concordance (0.304) (Figures 6.3 and 6.4).

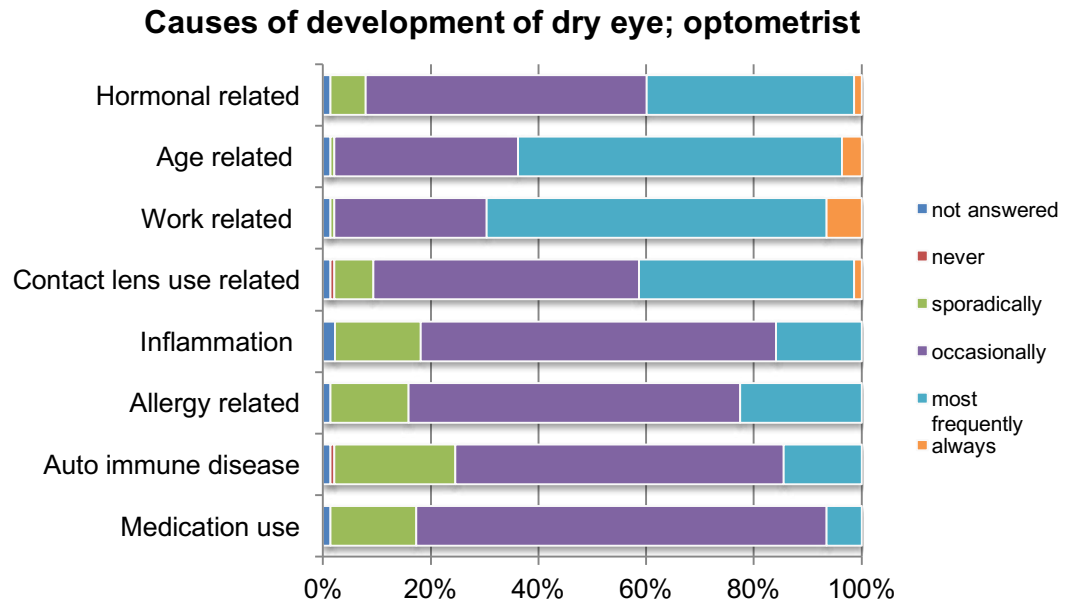


Figure 6-4 Causes of development of dry eye reported by optometrists.

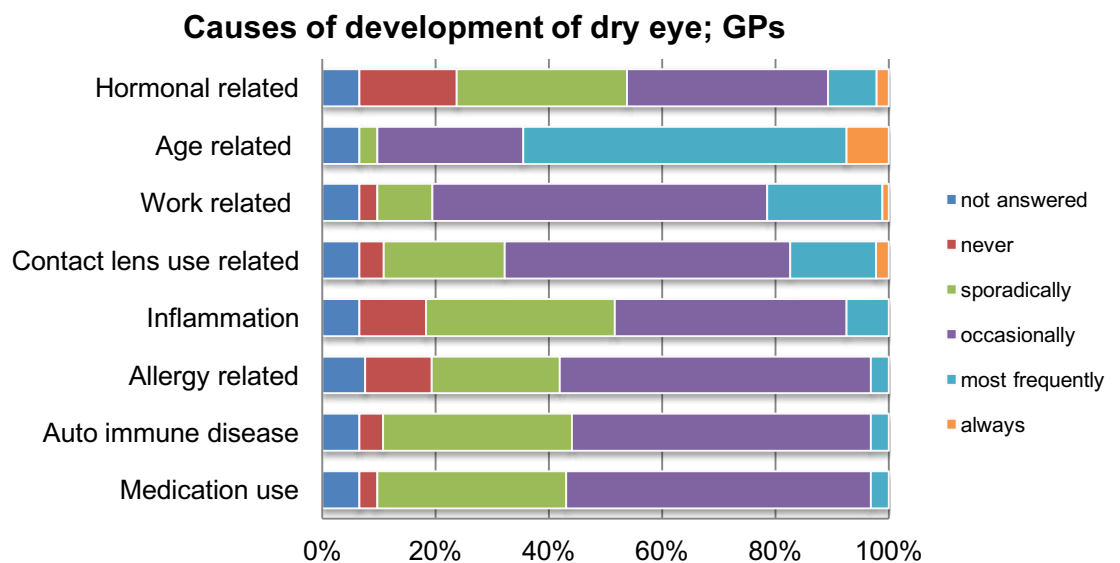


Figure 6-5 Causes of development of dry eye reported by GPs.

6.4.5 Reasons for developing dry eye

The frequency tables of reasons for developing dry eye reported by optometrists showed a tendency towards 'meibomian gland dysfunction' (MGD), with MGD showing the highest mean ranking, followed by 'anterior blepharitis' and 'soft contact lens wear'. There was a low agreement for this question among optometrists (Kendall's *W* concordance 0.178) (Figures 6.5 and 6.6).

Reasons of developing dry eye reported by optometrists

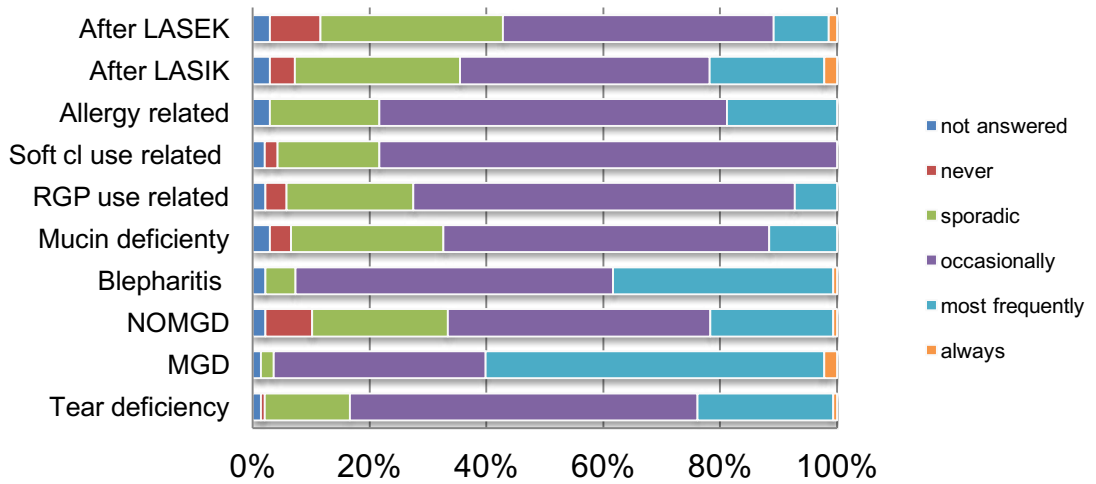


Figure 6-6 Percentage agreement in reason for developing dry eye indicated by optometrists;

LASEK: Laser epithelial keratomileusis; LASIK: Laser-assisted in-situ keratomileusis, NOMGD: Not obvious meibomian gland dysfunction; MGD: Meibomian gland dysfunction; Soft cl use: Soft contact lens use; RGP: Rigid gas permeable.

Reasons of developing dry eye reported by GPs'

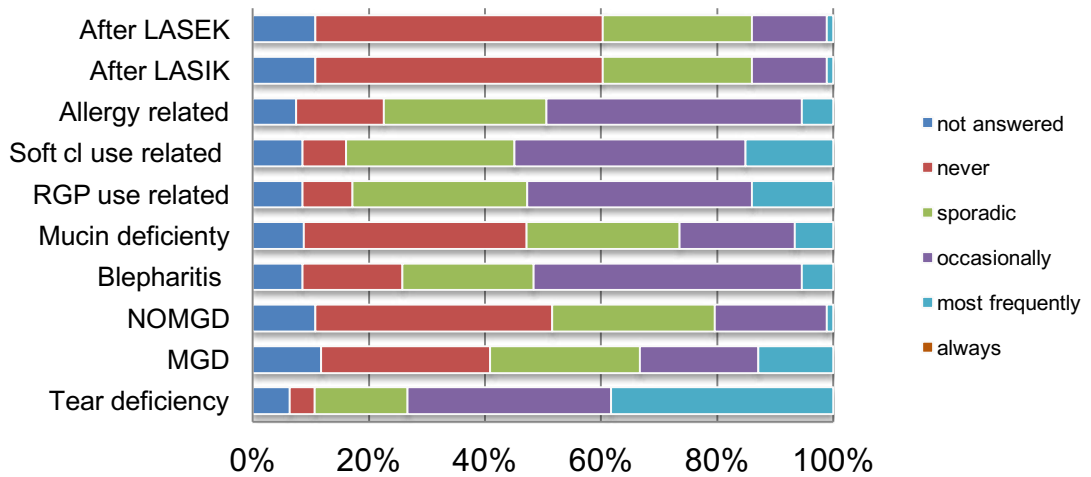


Figure 6-7 Percentage agreement in reason for developing dry eye indicated by GPs;

LASEK: Laser epithelial keratomileusis; LASIK: Laser-assisted in-situ keratomileusis, NOMGD: Not obvious meibomian gland dysfunction; MGD: Meibomian gland dysfunction; Soft cl use: Soft contact lens use; RGP: Rigid gas permeable.

The highest mean rank for the GPs was 'tear deficiency', followed by 'soft contact lens wear' and 'RGP (rigid gas permeable) wear'. The overall

agreement between the GPs was higher than the optometrists, but still low in general (0.313).

6.4.6 Use of investigative techniques

No agreement was found between GPs and optometrists on the use of investigative techniques for dry eye diagnosis ($p < 0.001$, Chi-square test). While Figure 6.7 shows that the optometrists use a variety of tests, Figure 6.8 shows that the GPs rarely use any of the diagnostic tests. The top 3 mean-ranked diagnostic test by the optometrists were 'tear break-up time (BUT)', 'lissamine green staining' and 'fluorescein staining', and for the GPs were 'lissamine green staining', 'osmolarity measurement' and 'tear BUT'. As for osmolarity measurements, out of the 87 GPs who answered this question, only 2 answered 'always' (2.3%), 3 answered 'most frequent' (3.4%), and 59 (67.8%) answered 'never'. Of all the other tests, the percentage of 'never using the test' dominated the outcome strongly. The Kendall's W test agreement for diagnostic test use by the GPs was 0.425, compared to 0.504 for the optometrists.

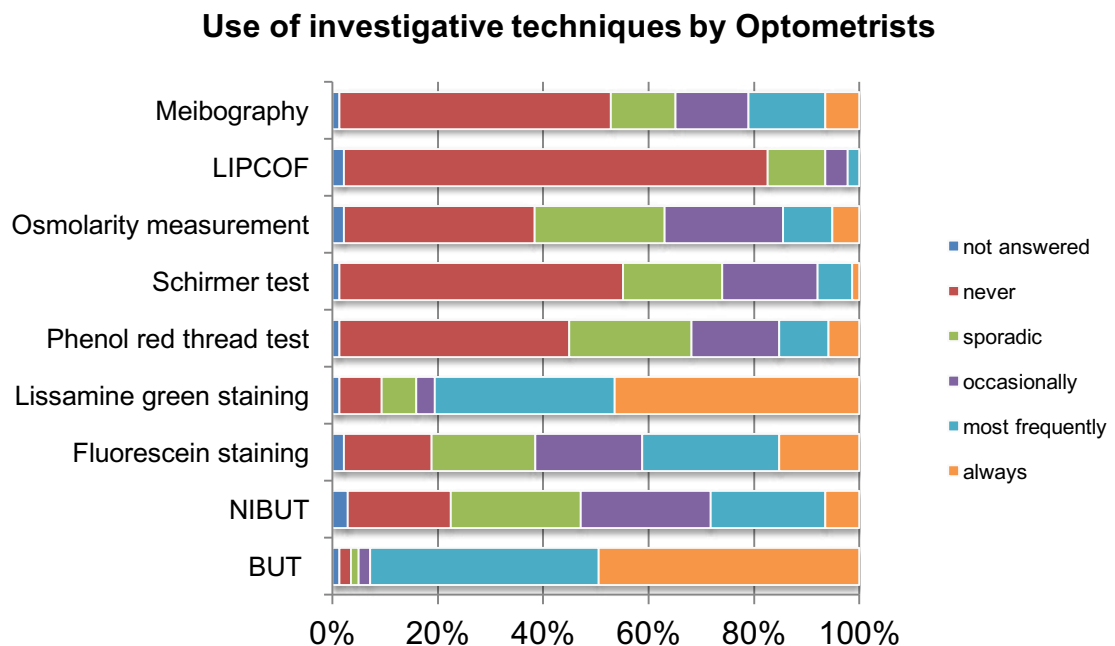


Figure 6-8 Percentage agreement for use of investigative technique, indicated by optometrists;

LIPCOF: Lid-parallel conjunctival folds; NIBUT: Non-invasive break-up time; BUT: Break-up time.

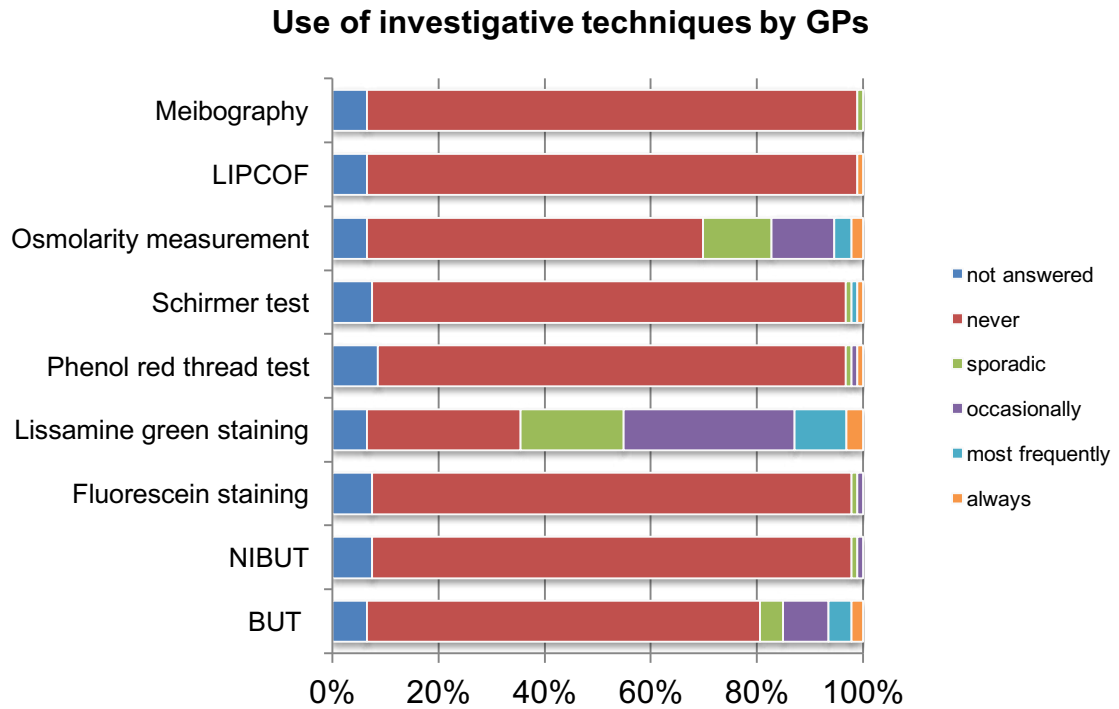


Figure 6-9 Percentage agreement for use of investigative technique, indicated by GPs; LIPCOF: Lid-parallel conjunctival folds; NIBUT: Non-invasive break-up time; BUT: Break-up time.

6.4.7 Prescribed treatment

The most commonly-used treatments for dry eye after diagnosis were investigated to discover habitual treatment methods. A statistically significant difference was found between the GPs and optometrists for ‘preserved artificial tears’, ‘unpreserved artificial tears’, ‘heat therapy’, ‘eyelid hygiene’ and ‘punctum plugs’ ($p < 0.000^*$), except for ‘gel/ointment’ ($p = 0.764$) (Figures 6.9 and 6.10).

6.4.8 Knowledge of recent research on dry eye disease

When specifically asked about their knowledge of the Dry Eye Workshop Report (DEWS) and the Meibomian Gland Disease Workshop Report (MGDW), there was a statistically significant difference between the GPs and optometrists ($p = 0.010$). The GPs had no knowledge of either the DEWS or MGDW reports (Figures 6.11 and 6.12), and while the optometrists showed more awareness of both reports, they had a weakness in detailed knowledge.

Prescribed treatment by optometrists

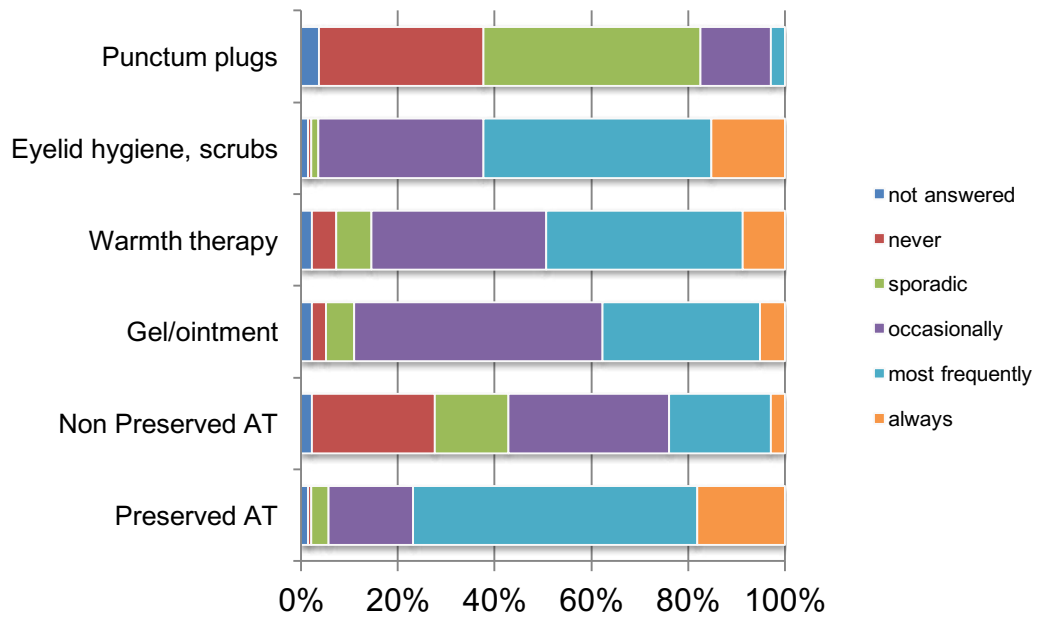


Figure 6-10 Prescribed treatment by optometrists, AT=Artificial tears.

Prescribed treatment by GPs

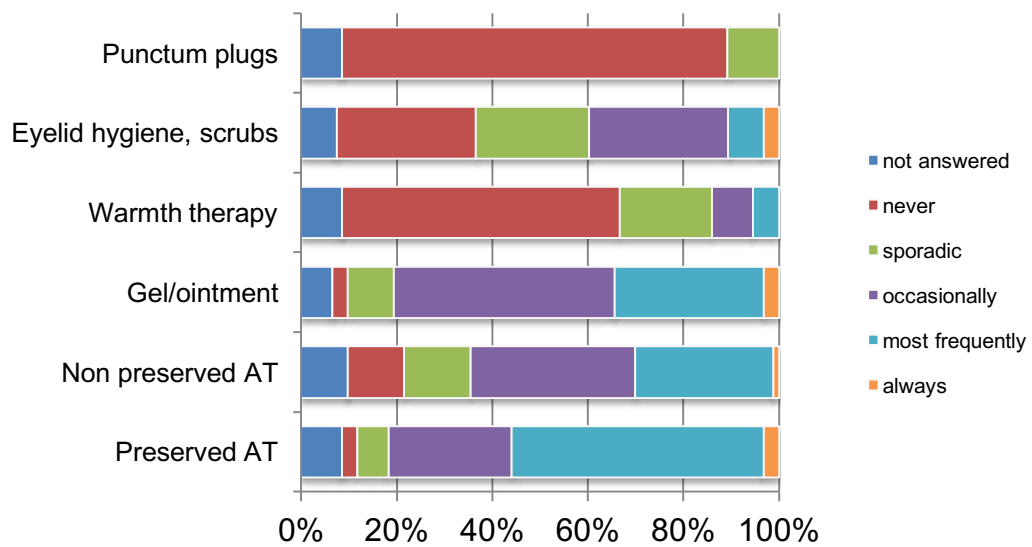


Figure 6-11 Prescribed treatment by GPs, AT=Artificial tears.

6.4.9 Co-management of dry eye in primary healthcare

Both optometrists (91.8%) and GPs (98.8%) reported that they did not frequently work together in the co-management of dry eye patients.

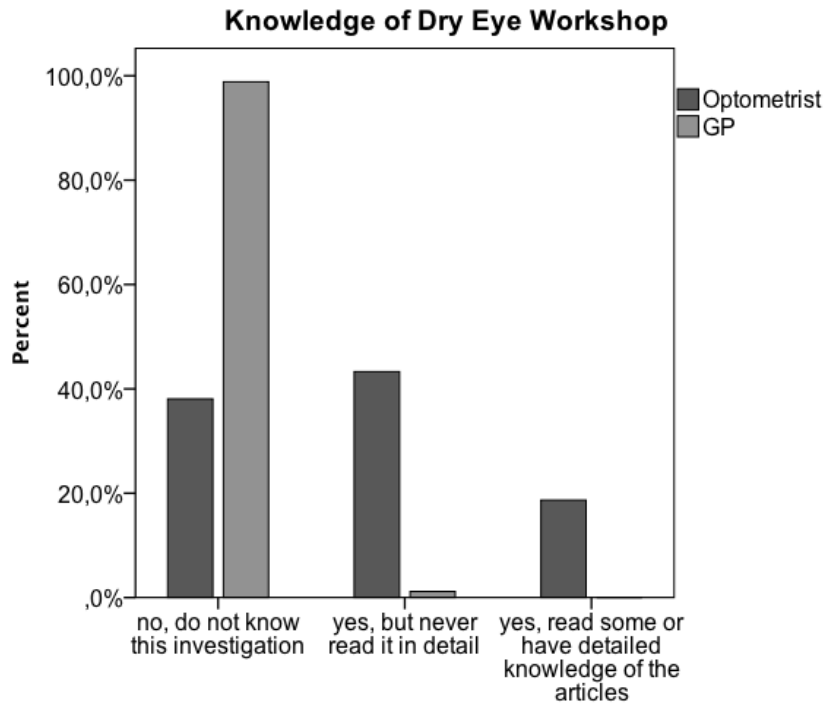


Figure 6-12 Percentage agreement for knowledge of the DEWS Report indicated by GPs and optometrists.

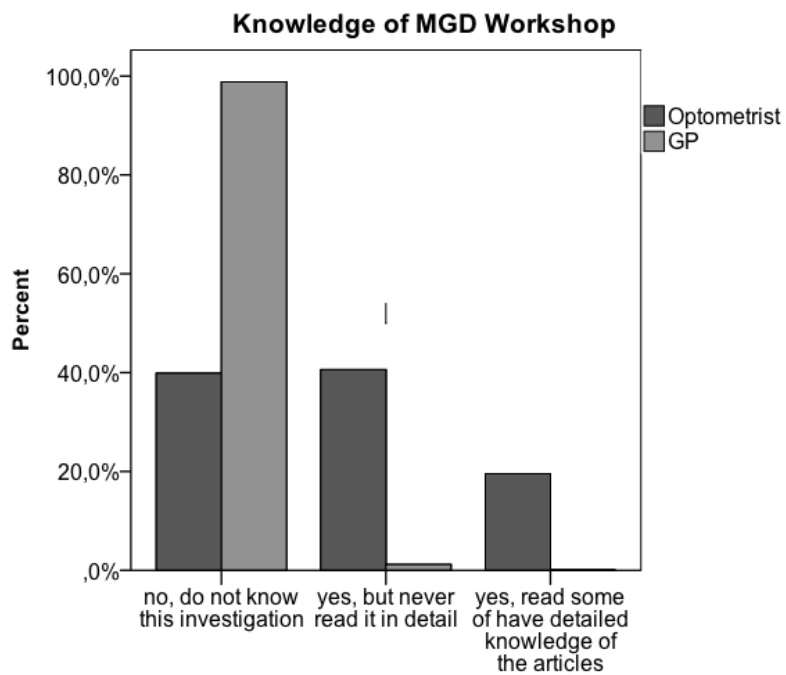


Figure 6-13 Percentage agreement for knowledge of the MGD Workshop Report indicated by GPs and optometrists.

6.5 Discussion

This survey has generated a better understanding of the daily practice of optometrists and GPs in the diagnosis and management of patients with DED in the Netherlands. Prior to this survey there was no information available on the attitude and method of care delivery for patients suffering from dry eye in the Netherlands when seen by optometrists or GPs. Indeed, to our knowledge, no research has been published that compares these two primary healthcare practitioners in the management of DED. There are several important findings that arise from the survey which have implications for future development of clinical care guidelines for the management of DED in the Netherlands. These findings also have relevance to primary healthcare clinical practice elsewhere.

The survey found significant differences between GPs and optometrists in the number of patients seen during a working week. Although some responses indicated having over 500 patient contacts per week, which seems excessive and may suggest a misunderstanding of the question, the relative differences between GPs and optometrists are clear. The median number of patients seen by the GPs during a week was 105 patients, and the median for the optometrist was 42. However, the number of dry eye patients seen per week was higher for the optometrist than for the GP: the GP saw on average of 1.78 patients with dry eye symptoms, while the optometrist saw almost 14 patients.

This latter difference may be because patients are more likely to report dry eye to an optometrist, or that the optometrist is more likely to ask about symptoms. The finding that the optometrist considers a wider variety of symptoms when making their diagnosis supports this perspective. Interestingly, the GPs results show a smaller standard deviation (1.77) compared to the optometrists (11.84) in dry eye patients seen. The small GP standard deviation suggests that seeing fewer dry eye patients is a consistent experience, whereas the greater variation for the optometrist might reflect the variety in the scope of practice for optometrists, some of whom might be working in a CL practice.

Despite a statistical difference, the similarity in patient age with dry eye symptoms without CL wear by both GPs (nearly 61 years) and optometrists (nearly 56 years) reflects one of the fundamental age related characteristics of DED. One of the best-known risk factors for developing dry eye is that it is more commonly found in patients aged 40 years and above.¹⁹⁰ The GPs and the optometrists were also similar on a younger average age, of 40 years, for soft CL wearers attending with dry eye symptoms. This is consistent with the latest findings in the Contact Lens Discomfort Workshop Report (CLDW) that CL wearers, compared to dry eye patients, experience more dry eye related problems at a younger age.^{18,191,192} Indeed, the first reporting of dryness symptoms during CL wear is typically around 20-30 years of age,¹¹³ and research shows that CL wear in a younger age population is a risk factor for ocular surface dryness-related problems.^{105,113}

The CLDW Report also stated that the association of CL wear with increased instability of the tear film due to MGD could be the main reason for patients developing CL discomfort.¹⁹³ So the agreement between GPs and optometrists on soft CL being a factor in dry eye symptoms has good foundation, but it is also worthwhile noting that GPs have almost no knowledge of the TFOS Reports on DED and on MGD.¹⁹² It is interesting, therefore, that GPs recognise soft CL wear as a source of dry eye symptoms, when they do not associate dry eye with other aetiologies. It would be interesting to know the source of this knowledge, and whether it is more related to anecdotal experience rather than any specific direction.

It is difficult to determine the real number of patients seen by both GPs and optometrists who have dry eye, but are not recognised as such. Generally, symptom questionnaires show the highest sensitivity and specificity for dry eye diagnosis supported with diagnostic tests.⁴¹ In this investigation, no specific questionnaire was used for DED, and the optometrists often used personally-designed questionnaires. This lack of uniformity could cause problems in communication between optometrists and GPs. The difference in diagnostic approach between GPs and optometrists may be observed through the symptoms that they each recognise as being specific for dry eyes, with only

'burning sensation', 'irritation of the eye' and 'tearing of the eye' seen by both as a specific symptom for dry eye. This is consistent with the literature as these symptoms are typically seen as dry eye related symptoms.^{16,194} The use of the other symptoms was statistically significantly different. Interestingly, there was a wider spread of symptoms recognised by the optometrists, who agreed less with each other than did the GPs, who had a shorter list of diagnostic symptoms. This might be accentuated if the survey responses for optometrists came from those in more specialised practice versus more general practice optometrists.

The frequency tables of reasons for developing dry eye reported by optometrists showed a tendency towards MGD, with MGD showing the highest mean ranking, followed by anterior blepharitis and soft CL wear. The highest mean rank for the GPs was tear deficiency, followed by soft CL wear and RGP (rigid gas permeable) wear. Interestingly, the higher ranking by the GPs for tear deficiency as a cause was not reflected in their response to the use of a specific diagnostic test, in particular to the use of the Schirmer test to confirm this as a possible reason. To detect MGD and anterior blepharitis, the use of a slit-lamp to provide a magnified view of the ocular surface as routine investigation technique is recommended, but this is usually only available to optometrists. When comparing the use of diagnostic tests, no agreement was found between optometrists and GPs. Indeed, GPs do not perform diagnostic tests as often as the optometrists. This may be due to having less time for each patient visit and/or access to specialised equipment needed.

Although more common for the GPs, the use of the Schirmer test by the optometrists was not a favourite. This may reflect a greater awareness by optometrists that the Schirmer test is no longer the first test used in diagnosing DED.¹⁹⁵ Nichols et al. (2000) found that only 8.5% of ophthalmologists in the USA used the Schirmer test for diagnosing DED.¹⁸⁶ The study also identified symptoms as the most preferred single test for diagnosing DED, with fluorescein staining second.¹⁸⁶ The Schirmer test was also preferred as the third or fourth diagnostic test by Spanish optometrists and ophthalmologists,¹⁸⁷ and Australian optometrists also reported limited use of the Schirmer I (5%), or

Schirmer II test (3%).¹⁸⁵ A much better overall diagnosis for dry eye is to use a combination of tests. Both Cardona et al. (2011)¹⁸⁷ and Pult et al. (2011)¹⁰² have reported that there is a need to combine tests with a dry eye questionnaire to increase specificity and sensitivity in DED diagnosis.

For the possible causes of developing dry eye, the only agreement between the GPs and optometrists was with age-related, which was the top rank, and which is consistent with the average age of DED patients they see in practice. Using the mean ranking, both the optometrists and GPs had work-related causes in their top three highest mean ranking. Although not shown statistically, the work-related cause may arise from common experience, since patients may complain of dry eye issues while at work.⁴⁹ The optometrists gave hormonal changes as a factor for developing dry eye, while the GPs had this cause as their lowest mean rank. Hormonal changes have been discussed as a possible cause for developing dry eye.¹⁹⁶ Female blood oestrogen levels and the menopause are known as predictors in developing dry eye.¹⁹⁷

Looking at the survey results generally, the GPs have a less extreme range of opinions than the optometrists, which could be explained by differences in knowledge and/or specialisation between the two healthcare professionals, or it could be due to a lower level of knowledge about dry eyes among the GPs. Also, the work experience of both professions was not taken into account and this could influence their responses. Similarly, the population type and average age of the patients seen in routine practice could also influence the answers given. A study investigating diagnosis of eye pathology and DED between GPs and ophthalmologists in the UK found that these were all factors,¹⁹⁸ but any similar study has not been done in the Netherlands, to the author's knowledge.

More GPs did not complete all the questions. For the investigative techniques, this can reflect either that the tests were unfamiliar, that the tests are not used in a normal GP practice, or that they are seen as being unusable in a GP practice. In general, the trend in this study is that the GPs do not frequently use any of the diagnostic tests. There were also some unusual answers for a few GPs who report using tests for diagnosing DED, such as lissamine green,

osmolarity measurement and BUT – osmolarity measurement is not a common test, nor is the use of lissamine green, compared to the more commonly-used fluorescein.

In the survey of treatment options, agreement was only found between optometrists and GPs in the 'prescribing of gel/ointment'. Also, the optometrist more often prescribed artificial tears without preservatives, while the GPs prescribed them with preservatives. The reluctance to use artificial tears with preservatives by optometrist could reflect a greater awareness of the latest opinions about preservatives.¹⁹⁹ In contrast, the GPs motivation may be influenced by the fact that artificial tears with preservatives can be reimbursed by health insurers, although this aspect was not specifically investigated in this study. In contrast, optometrists are more focused on other treatment options, such as 'lid hygiene' and 'warmth therapy'. More often than the optometrists, GPs prescribe drops and ointments with and without preservatives. This goes against the MGD Workshop Report which states that it is particularly inappropriate and inefficient to use artificial tears with dry eye patients who have an evaporative aetiology.²⁰⁰

While the analyses are not specific enough to make a statement about the behaviour of the optometrist in managing the dry eye patient, it seems that the optometrist is more focused on eyelid disease, such as blepharitis and MGD. Since their "standard" equipment is more likely to include a slit-lamp and their education towards the anterior segment includes assessment and diagnosis. In contrast, it appears the GPs approach is more subjective-based (symptoms) than objective-based (tests). This may reflect the finding that dry eye investigative techniques are not performed as a standard procedure, which itself may be due to eye care forming just a small part of their daily work. Such a view is evident from the high numbers of GPs who do not perform dry eye tests on their patients, and from them having less knowledge of the recent research of DED.

There is a risk arising from this that GPs may not be making the right decision towards therapy given, and, by treating the symptoms, the underlying cause

may not be considered, since the prescription of artificial tears may not be the most effective therapy for a lot of patients with dry eye symptoms due to Blepharitis or MGD.^{201,202} This inappropriate treatment will have led to an increase in the cost of healthcare, and the in-effective treatment could lead to unnecessary referrals to ophthalmologists for further investigation.

Overall, the variety in answers given by optometrists in the Netherlands shows a lack of uniformity in the use of investigative techniques, in the therapeutic options given, and in the symptoms associated with dry eyes found in their practices. This lack of uniformity was also observed in the Downie et al. (2013)¹⁸⁵ investigation of Australian optometrists, which studied their use of investigative techniques, management and evidence-based guidelines for dry eye diagnosis and management.

How can the results of this study be applied to improve primary care practice for DED management in the Netherlands? A consensus of treatment options for dry eye was first put forward by Behrens et al. (2006),⁴⁸ that was later included in the recommendations of the DEWS report, with some adjustments made later by Latkany (2008).²⁰³ This consensus proposed treatment options related to the severity of the dry eye, tear film quality or quantity, the presence of (corneal) staining, and the symptoms of dry eye. Early treatment options include nutritional advice and education about the environmental factors that can affect the tear film. Regardless of what is proposed in the literature, the evidence of this study is that none of these treatment “guidelines” are incorporated into day-to-day GP or optometry practice in the Netherlands.

The need for, and content of, guidelines and plans of management for a health condition is frequently a source of debate in all parts of medical practice, and is also true between dry eye specialists, ophthalmologists, optometrists and cornea specialists.¹⁸⁵ However, the evidence from this study shows that there is an urgent need to establish better management guidelines for DED in the Netherlands that includes GPs, optometrists and ophthalmologists in a manner beneficial to patient care.

6.5.1 Limitations

This investigation does have some limitations, primarily from the difference in numbers of optometrists and GPs recruited. This might be due to the different recruitment methods used. For the optometrists, they received an invitation via the optometric board and a known investigator, while the GPs were sent an email directly by the investigator, who was unknown to them. Since only GPs with an open-access email address were invited, this could mean that only a selective group was invited. These differences could influence the response in both positive and negative ways. Moreover, several different participation emails were sent, which could entail the possibility of over-asking the GPs and could negatively influence their response. On the other hand, the good concordance in answers from the GPs gives some confidence that their training and responses are consistent. For both optometrists and GPs, there was no question asking about the scope of practice or the years of experience, which would also be an interesting aspect that could reflect differences in educational training and clinical experience over time. A suggestion of educational influence might be drawn from the higher number of unanswered questions for the GPs, which could imply an unfamiliarity with the topic.

Consideration of the care pathway for DED would not be complete, especially when looking at those working in an office environment, without involving the occupational healthcare physician (OHP). In this investigation, the OHP was not involved since they are involved in directing any work-related management options, rather than the primary diagnosis and therapy options given by the GPs, optometrists and ophthalmologists.

6.6 Conclusion

The investigation, diagnosis and treatment of DED varies significantly between optometrists and GPs in the Netherlands. Co-management should be the next step to strengthen this area of primary eye care in the Netherlands. The optometrist is performing more specific tests and sees more dry eye patients per week, but the level of variance between optometrists indicates that clear guidelines on dry eye management are needed. There is a need for continued

education to communicate the role each healthcare professional should play to promote the best patient access to the knowledge and expertise of each professional in the management pathway for DED in primary healthcare.

6.7 Next step

Next to age-related DED, work-related dry eye was in the top three ranking of cause for dry eye by both professions, with optometrists reporting a higher percentage of patients with work-related dry eye than GPs. When the symptoms seem work-related, management options can be more challenging, since the work environment and visual tasks involved can play a role in the development of dry eye symptoms. Currently, the impact of work-related dry eye symptoms on office workers in the Netherlands is unknown. It is also unknown whether the therapeutic-based management given by GPs and optometrists is efficient and effective, or if the OHP has a role in preventing dry eye related symptoms in offices.

A presentation was given, based on this research, at the BCLA conference 7 June 2014:

“Dry eye care in primary healthcare in the Netherlands, Optometrists vs GPs”.

An article based on this research has been published in:

Van Tilborg MMA, Murphy PJ, Evans KSE. Agreement in dry eye management between optometrists and general practitioners in primary health care in the Netherlands. *Cont Lens Anterior Eye* 2015; 38: 283–93.

7 The requirements for a dry eye management healthcare model for by GPs, OHPs and Optometrists in the Netherlands

7.1 Dutch Healthcare System

The Dutch Healthcare System has the GP, at the primary level of healthcare, acting as the gatekeeper for secondary healthcare, and has the optometrist educated as a primary eye (health) care profession.

The Institute of Medicine (IOM) (1996) provides the following definition of primary healthcare: *“Primary care is the provision of integrated, accessible healthcare services by clinicians who are accountable for addressing a large majority of personal healthcare needs, developing a sustained partnership with patients, and practising in the context of family and community.”*

The healthcare system in the Netherlands is currently under government review, as it is recognised that the current system will not be affordable in the near future, due to the large population of ageing citizens. The Dutch Government published a report “Moving towards new healthcare and new healthcare professions: the contours” (Kaljouw Report, April 10th 2015)²⁰⁴ on the future of care and healthcare professionals, and divided future care into 4 domains (ABCD model): A; “pre-care” (screening, primary healthcare); B “community-care” (healthcare in and around the home); C “low complex care”; and D) “high complex care” (Figure 7-1). Low complex and high complex care are those needed for functioning, and are similar to the present secondary healthcare system and, partly, to the tertiary healthcare system. It is anticipated that pre-care will become more important than the current primary level of healthcare:

Pre-care is about the entire Dutch population and it focuses on promoting healthy life. Pre-care is a social matter that involves many domains, including healthcare. This is only possible with an integrated approach and attention being paid to health skills in teaching, work, the

neighborhood and healthcare. Pre-care focuses on developing resilience and on health risks by means of health promotion, health protection and disease prevention, both individually and collectively.

Low-complex to more-complex forms of care is 'basic care and specialised care, for both acute and planned situations, with a high level of predictability regarding the required deployment and the course (of diseases/disorders). Assessment and grounds are determined in advance of treatment. Functioning is the point of departure. What must always be examined is what is necessary and not what is possible. Technology also plays a major role in C (low to complex care), not only during treatment, but also with regard to communication and information.

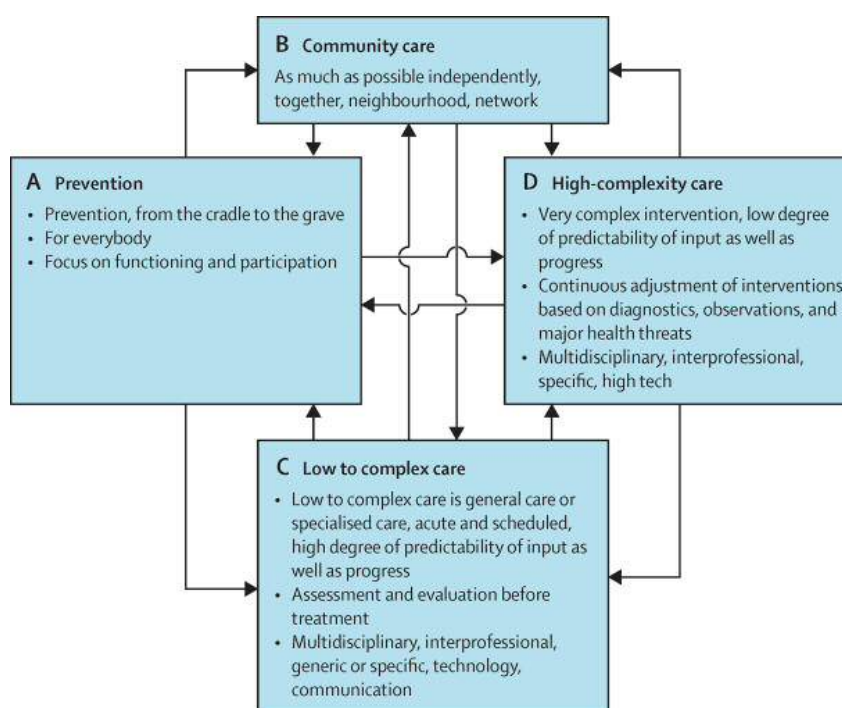


Figure 7-1 Schematic diagram of the 4 healthcare domains in the Kaljouw Report ABCD model (2015).1

Although the report was mainly focused on care for the ageing and on the growing population with dementia, there is a discussion, in optometry, around whether their role in the model should be in pre-care or low-complex care, or in both, e.g. a diabetic retinopathy scheme could be managed in pre-care between GPs and optometrists, and in low complex care with optometrists and ophthalmologists.

For developing a management pathway for Dry Eye Disease (DED) the Chronic Care Model (Figure 7.2) can be used as a guideline. The Dutch Government is already looking at implementing the chronic care model for other chronic diseases, such as Diabetes and Chronic Obstructive Pulmonary Disease (COPD), after it was concluded that the current health system is not complementary with the needs of a fast-growing population with chronic disease.¹²⁴

The chronic care model describes an “organised healthcare system”, which implies a healthcare system, with professionals working together for improved patient care.²⁰⁵ The World Health Organisation (WHO) has said that inter-professional education is needed to enable successful collaboration and to develop patient-centred care. WHO states that: “*Inter-professional education occurs when two or more professions learn about, from and with each other, to enable effective collaboration and improve health outcomes.*”¹²³

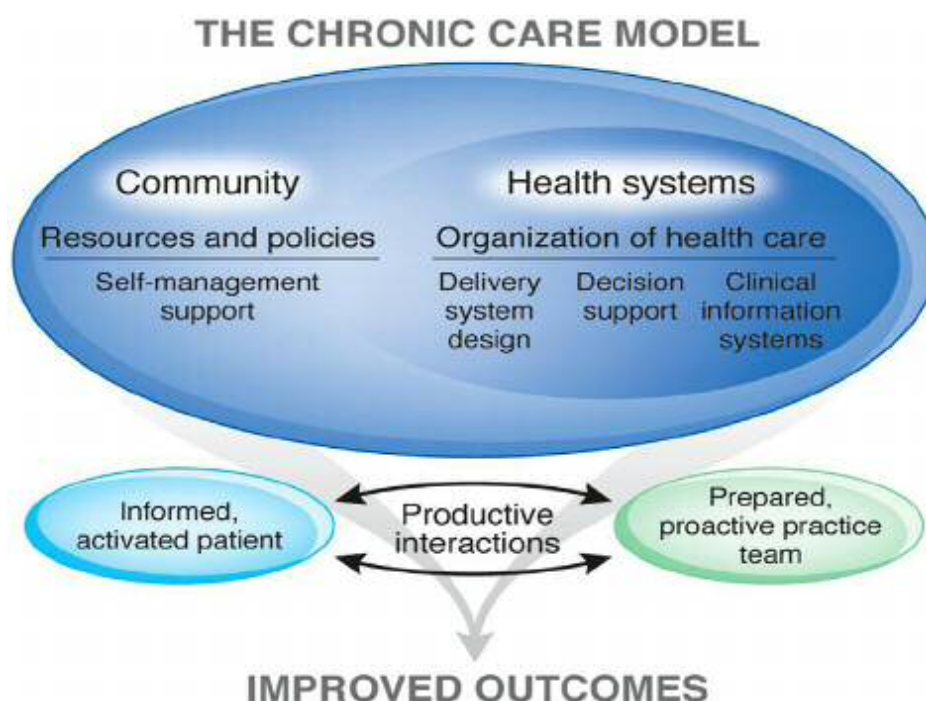


Figure 7-2 The chronic care model, as developed by Edward Wagner (1990).

These changes will have an impact on the management of DED. Under the current healthcare system, a patient who consults a GP with their complaint will be either managed by the GP or referred to an ophthalmologist. If the DED is

causing absence from work, the employer will report this to their occupational health-service provider. When the sick-leave exceeds 6 weeks, the employee has to be reviewed by an occupational health physician (OHP)¹¹⁷. For OHPs, it is preferable to know if the patient with DED has received proper treatment for their symptoms and what is needed to help the DED patient in a compromised environment, such as an office building, or what might be the effect of long hours of reading using electronic devices in a controlled airspace on these symptoms. If the symptoms are aggravated by the environment,^{125,152} and if the worker's illness perception and quality of life are compromised by having DED, this may negatively influence work productivity.^{30,149,206} If the treatment is the best available, then other aggravating factors need to be acknowledged and other healthcare professionals may need to become involved to improve the environment for the patient and allow them to function better in daily-life.

In neither of these two scenarios is the optometrist typically involved, but, in the new model, DED management could be moved to the optometrist as low complex care. Brouwer (2012) used data from NIVEL to show that over 40,000 patients could be moved from GP care, if the DED patient was able to go directly to the optometrist.¹¹⁹ However, the results from Study 4 showed that there is a lack of understanding of DED and clinical care pathways amongst GPs and optometrists.¹⁴⁵

7.2 Investigation by the Delphi method

To investigate this lack of understanding, and to consider options for the development of a clinical care pathway for DED management, this study used the Delphi method of structured communication to facilitate discussion between GPs, OHPs and optometrists.

The Delphi method is used in science, social science, and healthcare research, and is a proven, valuable tool to develop consensus for guidelines, care systems or profiles, screenings protocols, diagnosis, and treatment.^{207,48,64} A Delphi study is a virtual meeting of experts, with the purpose of reaching consensus on the presented topics. By keeping the responses anonymous for

all panelists, each expert is able to give their comments without the social pressure of a group.^{207,208} As the Delphi method depends principally on the participation of experts, it is not dependent on statistical power. In the literature, the recommendation for expert group size is 10-18 experts, although some promote larger working groups.^{207,208}

7.3 Objectives of the study

This study aimed to investigate the needs, wishes, attitude and willingness of GPs, OHPs and optometrists in managing mild/moderate DED, by use of the Delphi method. The findings will assist in the development of a theoretical clinical-care model for DED in the Netherlands.

7.4 Method

7.4.1 Experts

The respective professional bodies of the three healthcare professionals were informed about the project: OVN (Optometry Association Netherlands), NVAB (Netherlands Society of Occupational Medicine), and NHG (Dutch College of General Practitioners), and each was asked to allow an invitation to be sent to their members to take part in the study. With permission obtained, the following steps were taken:

- For the optometrists, an email invitation (via a web-link) was placed in the OVN association newsletter sent to their members (over 1200 members), and a reminder was also placed on the private Facebook account of the OVN. In total, **20 optometrists** agreed to participate.
- For the OHPs, an email invitation (via a web-link) was placed in the NVAB newsletter (over 2000 members). In total, **13 OHP** panelists were recruited.
- For the GPs, an invitation was sent by email to 1326 open-access GP email addresses, throughout the Netherlands, in May 2016. Of these, 355 opened the email invitation, 847 did not open it, 65 re-bounded and 15 sent a message back declining the invitation. In total, **13 GPs** were

willing to participate. A reminder of the invitation was sent twice to the GPs by email.

7.4.2 Inclusion criteria

The following inclusion criteria were applied for panel members:

To participate it was obligatory to have at least 2 years of experience in practice. Optometrists needed to work mainly in primary healthcare, OHPs needed to see clients who were working in office buildings, and GPs needed to work in private practice. There were no selection criteria on age or gender.

When the panelists agreed to participate, the researcher confirmed their participation, by email, and provided them with details concerning the Delphi method and how they should respond to the first email sent at the start of the investigation. The study protocol was approved by the Human Research Ethics Committee of the School of Optometry and Vision Sciences at Cardiff University, and was consistent with the tenets of the Declaration of Helsinki.

7.4.3 Delphi Method

By using the Delphi method, expert judgements are used and compared, in several rounds, with the collected judgements of other panel experts. Through an iterative approach, the questionnaire is gradually refined to achieve a series of agreed statements. In this investigation, 3 rounds were needed to gain consensus on the asked criteria (Figure 7-3).

In each round, the experts were asked to rate their response to a series of questions/statements by forced-choice Likert scaling: not important (1), moderately important (2), important (3), and very important (4); or: do not agree (1), moderately agree (2), agree (3), and strongly agree (4). Panelists were encouraged to make comments and suggestions on any of the issues in the survey. The panelists were also encouraged to suggest alternate questions/statements that better represented their opinion. When panelists suggested a change to the question/statement, or gave a valuable addition to the question/statement, and when they were considered to be multi-disciplinary

in effect, the comments were included in subsequent rounds for all the professions. A reminder for response was sent twice, by e-mail, to each panel member to complete the questionnaire.

The investigator coded the answers to the questions to create an overview of the specific answers given. Descriptive statistics were calculated. Consensus was said to be reached when there was a >70% agreement (combining the 'important/very important', or the 'agree/strongly agree' Likert responses), and excluded or re-phrased when the response was >50% to a negative answer.

After receiving the response of the panelists, the next set of questions/statements was sent within 3 weeks. Once again, the questions were rated on consensus and on vital changes to the question or the additional response to the question. The adjusted questions were rated again by the forced-choice Likert scale. This process was repeated twice to produce a final version of the questionnaire.

Anonymity of the panelists is one of the keys of the Delphi method, allowing each panelist to express their opinions without any social pressure. Other key features are to allow panelists to change or adjust their view (called the iteration), and for the investigator to control the feedback given, to inform panelists of other views of the group, and to undertake quantitative analysis and interpretation of data drawn from statistical aggregation of the responses for each group.^{207,208} All responses from the questionnaires were kept anonymous to ensure confidentiality of information. Each panelist's participation was also kept confidential from the other panelists.

7.5 Preparation of Surveys

The questions in the first round were the same for all professions. These questions were based on previous findings by the author on the knowledge and responsibility in DED management for each profession. The aim was to obtain information on the perceived attitudes towards the current care pathway for DED patients, and on the current ideas in each profession about visual

functioning, and the impact on daily functioning from having DED symptoms. More specifically, questions were asked about each profession's opinions on the need for an optometric examination in primary healthcare or on the need for patients to have optometric eye care in primary healthcare.

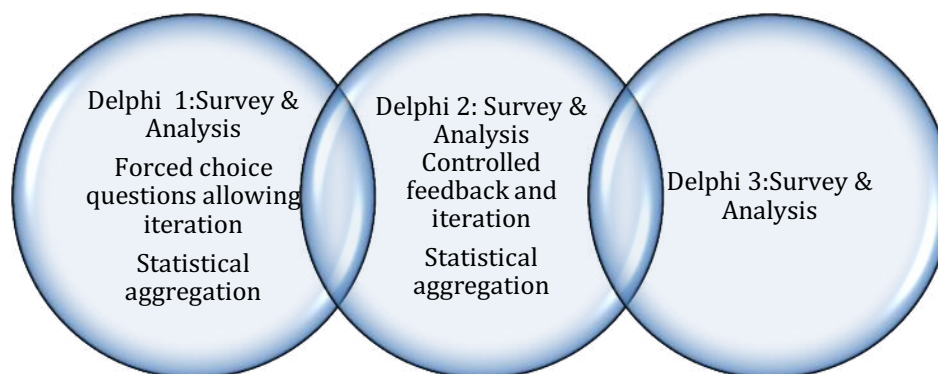


Figure 7-3 Outline of the three rounds used in the Delphi survey.

7.6 Method; Delphi Round 1

The first round was composed of a set of questions/statements containing 24 forced-choice questions and 1 open-answer question concerning the wishes and needs towards a care system. The first 2 forced-choice questions considered common DED symptoms and their impact on daily activities and work productivity, and their influence on visual functioning during the day (Figures 7-4 and 7-5).

Of the remaining 22 questions (Table 7-1), the questions were divided into 5 sub-categories: 1. Knowledge, diagnosis and management (7 questions); 2. Healthcare (3 questions); 3. Who will be or can be the specialist in primary dry eye care (5 questions); 4. Wishes and needs (5 questions); 5. Role in the care model (2 questions).

The first questions focused on each profession's knowledge of DED and knowledge of competencies of the two other healthcare professionals; and then continued with questions about whether there is a need for another (new) professional/coach for DED in primary healthcare, and, if so, who that person would be; and whether the status of the optometric consultation not being

covered by healthcare insurance is a barrier for referral to an optometrist. The last 2 questions focused on the role each professional would fulfill in a care system for DED: diagnosis, management, prevention and referral.

7.7 Method; Delphi Round 2

A lack of knowledge was apparent in the GPs and OHPs regarding the vocational skills and knowledge (competencies) of the optometrist, and so the core competencies, as written in the OVN professional code, were given to the panelists to assist them in completing the forced-choice questions about the scope of practice and role of the optometrist.

Delphi Round 2: Optometrists

The optometrist panel received 16 questions/statements related to knowledge, skills and responsibility in DED management, knowledge of the Kaljouw Report, and their role in the current healthcare situation, based on their response to statements in Round 1.

Delphi Round 2: OHPs

For the OHPs, 15 questions/statements were sent for Round 2, 14 to further investigate the opinions given by the OHPs to the questions in Round 1, and 1 on the scope of practice of the optometrist. This last question/statement was also answered by the GPs.

Delphi Round 2: GPs

In Round 2, in response to the feedback from Round 1, only 10 questions were presented to the GPs, with the first 2 questions asking whether they believe that the optometrist has (in their opinion) the competences for primary care and public health, as described in the Kaljouw Report, and the remaining 8 questions were based on those questions to which no consensus was found in Round 1.

7.8 Method; Delphi Round 3

For all panels, the final open question was asked: “What, to their best belief, is needed for each profession to create the best healthcare for DED patients?”. This could be interpreted as the need for a healthcare system, working inter-disciplinarily, working in a multi-disciplinary team, or as a need for another profession.

Delphi Round 3: Optometrists

The optometrists were asked whether they believe the optometrist has the competencies in primary care and public health, as described in the Kaljouw Report. The 4 remaining questions/statements were about the education they have received about healthcare systems.

Delphi Round 3: OHPs

The OHPs were asked whether they believe the optometrist has the competencies for primary care and public health, as described in the Kaljouw Report. An additional question/statement was asked about a multi-disciplinary approach across local, regional or professional boards

Delphi Round 3: GPs

The GPs had no additional focused questions/statements in Round 3.

7.9 Data collection and protection

Co-ordination of the data collection and protection of data was undertaken by one investigator (MvT), with the data accessible by the other researchers named in the ethics application. The questions were hosted on the SurveyMonkey.com website, and all completed surveys were stored on a password-protected database. Access to this database was secured using a log-in code and password. The data was converted to a text format for statistical software analysis.

Descriptive statistics were calculated for the set of questions using SPSS 24 for MAC (IBM Inc, USA). Ordinal variables were derived from the Likert scales to

categorise the strength of agreement and facilitate statistical analysis. A Pearson's Chi-square test was used to compare differences in given answers among the optometrists, OHPs and GPs. The Kendall's W test (coefficient of concordance) was used to value the agreement amongst the three professions. A Kendall's W outcome of 0 indicated no agreement and of 1 indicated complete agreement. A p-value of <0.05 was considered to denote statistical significance. Frequency tables were constructed for questions asked at Delphi Round 2 to provide an overview of the responses given by the different groups. To analyse the adjusted questions or added information, the responses per question were set in a spreadsheet to code the question or comment.

7.10 Results

Of the initial 20 optometrists, 14 optometrists completed all 3 rounds, with 3 stopping after the first round; of the initial 13 OHPs, 11 OHPs completed all 3 rounds, with 2 stopping after Round 1; and of the initial 13 GPs, 11 GPs completed all 3 rounds. Two of the optometrists responded after reading Delphi Round 1 that the topic and questions about care systems were not of relevance to them. No detail was given by the two OHPs or GPs for dropping out.

7.11 Round 1: Impact on visual functioning and daily activities from DED symptoms

The first 2 questions asked about symptoms and their impact on daily activities, work productivity and visual functioning during the day. No significant difference in perception of influence on work productivity was found between the three professionals (Figure 7.4). However, a statistically significant difference was found for the impact on visual functioning from having symptoms of 'tired eyes' or 'pressure on or behind the eyes' ($p=0.039$ and $p=0.014$, respectively), with the GPs feeling that these symptoms had less interference on visual functioning (Figure 7.5).

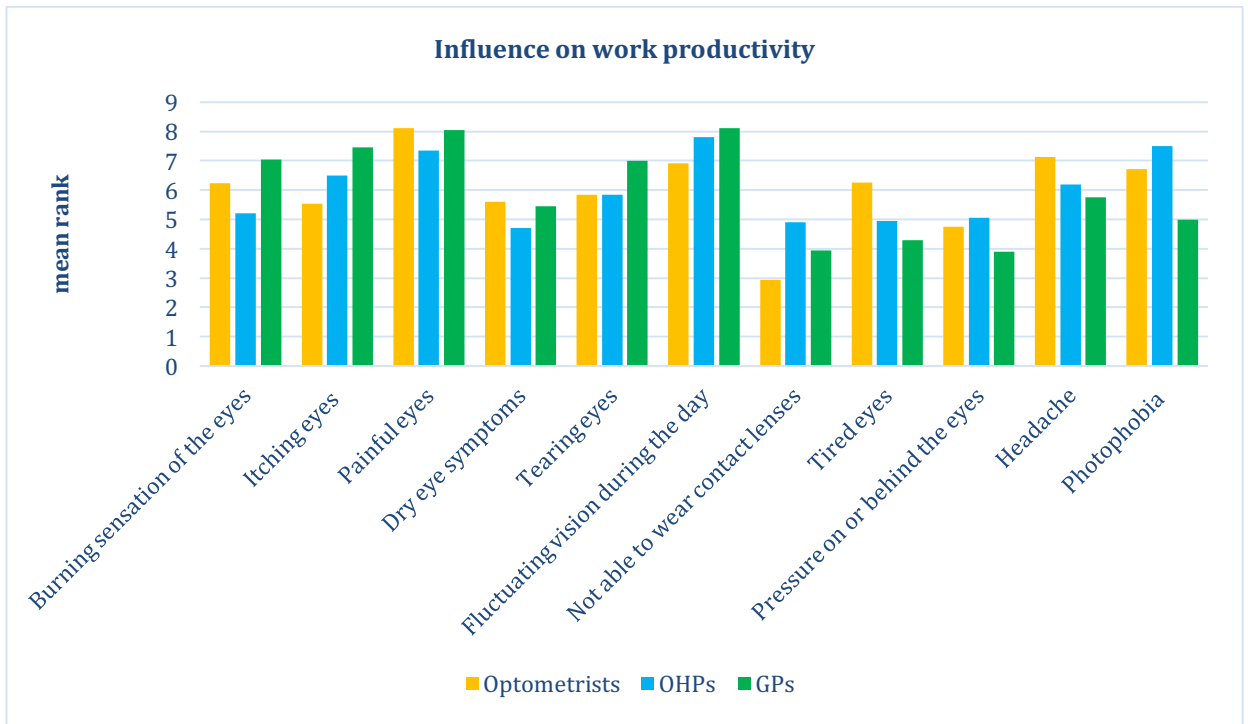


Figure 7-4 Mean rank of the possible influence of symptoms on work productivity, 0 means no influence; 4 means great influence. Kendall's W: Optometrists = 0.250; GPs = 0.344; OHPs= 0.220. No statistical significant difference was found between the groups.

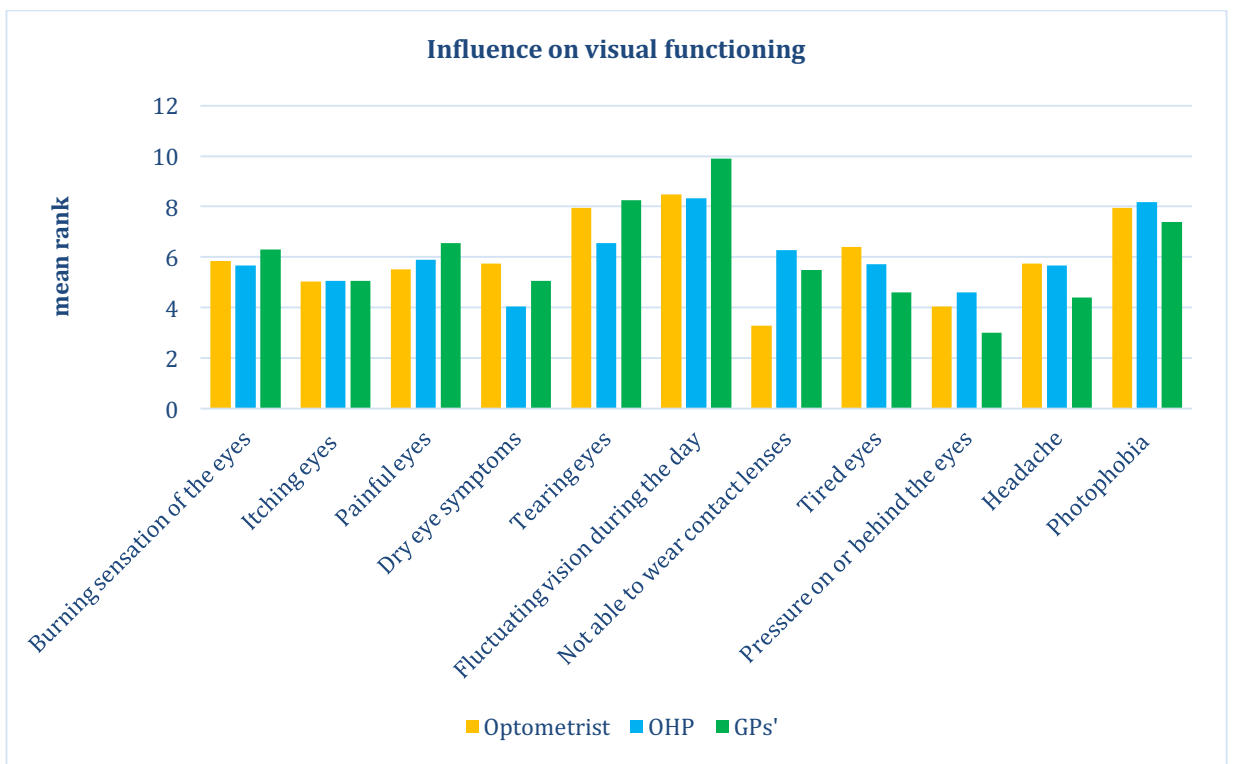


Figure 7-5 Mean rank of the possible influence of symptoms on visual functioning during the working day Kendall's W: Optometrists = 0.329; GPs = 0.434; OHPs = 0.252. A statistical significant difference was found for 'pressure on or behind the eyes' (p=0.014), and 'tired eyes' (p=0.039) (chi-square).

For the remaining 22 questions, the Kendall's *W* test found that the optometrists and GPs had a similar trend of internal agreement, (0.496 and 0.457, respectively), whilst the OHPs had a lower internal agreement (0.258) (Table 7-1). The questions were categorised in knowledge, healthcare, who is the specialist, wishes and needs, and role in the health model.

7.12 Knowledge, diagnosis and management

Of the 22 questions asked to the optometrist panel, a >75% agreement was reached (Table 7-1) for 19 questions, clustered by topic asked. Their main area of concern was about the possible level of knowledge of GPs in DED. The OHPs showed a similar pattern as the optometrists (Figure 7-7), with the difference that the OHPs had problems understanding the current knowledge and skills of both the GPs and optometrists in DED.

The GPs showed a similar consensus on the need for knowledge regarding DED as the optometrists and OHPs. The GPs had some concern about the integrity of optometrists, regarding the possible thin-line between care and commerce. The GPs questioned whether dry eye is a disease, as they see dry eye as a common age-related issue.

7.13 Healthcare insurance

The question of whether the issue of the optometrist not being covered by health insurance, when referring patients, was felt by all optometrists to be 'important' or 'very important', except for one optometrist who had an arrangement via the Ksyos system (an e-health system developed primarily for diabetic fundus screening).

The OHP consensus was that it will play an important role in discouraging the referral of patients to an optometrist. The GPs also felt that it plays an important role, with one GP suggesting that, with a good explanation by the GP, the patient will choose to go to an optometrist, and another GP asked what a consultation would cost.

Table 7-1 List of questions asked in Round 1, with their mean Likert score for each profession.

	Optometrists		OHPs		GPs	
	Mean	Sd	Mean	Sd	Mean	Sd
Knowledge, diagnosis and management						
I think there is a need for in-depth knowledge about the condition of dry eye and dry eye symptoms.	3.50	0.52	3.00	0.58	3.11	0.60
I think there is a need for in-depth knowledge of DED and possible treatments.	3.50	0.52	3.29	0.76	3.22	0.67
I think there is a need for in-depth knowledge about the impact of dry eye on the work productivity of people with dry eye symptoms.	3.50	0.52	3.00	0.58	3.00	0.00
I think there is a need for in-depth knowledge about the disease perception of people with dry eye symptoms	3.08	0.52	3.00	0.58	2.78	0.44
Seen from the client / patient; I think in primary care more knowledge is needed about the impact of dry eye on daily functioning.	3.58	0.67	2.57	1.81	2.22	1.30
Seen from my client / patient; I think there is a need for more knowledge of DED and treatment methods at optometrists	3.25	0.62	3.14	0.69	2.67	0.50
Seen from the client / patient; I think there is a need for more knowledge of DED and treatment methods for GPs	3.58	0.51	3.00	0.82	3.11	0.60
Healthcare						
DED diagnosis and management belongs in the first line healthcare	3.83	0.40	2.86	0.69	3.56	0.58
The diagnosis of DED may be made only by an ophthalmologist in my opinion.	1.50	0.52	2.30	0.76	1.33	0.50
I think the GP is the primary professional for the treatment of dry eye.	1.58	0.51	2.71	0.76	2.89	0.60
Who will be or can be the specialist in primary dry eye care						
I find that the optometrist can be the primary professional in the first healthcare for the treatment of dry eye.	3.92	0.29	3.00	0.58	2.89	0.60
Dry eye problems I see as optometric care	3.83	0.39	2.57	0.53	2.44	0.88
I think there is a need for a professional who has the lead in the management of DED.	3.42	0.67	2.71	0.76	2.22	0.83
I find that a specialist professional will investigate, treat and supervise the management of DED.	3.00	0.85	2.57	0.98	2.00	1.00
Optometric care is not covered care by insurance, do you think that that would play a role to refer or get referrals	3.08	0.51	3.29	0.76	3.22	0.83
Wishes and needs						
In the eye-related symptoms, there is a need for receiving the clinical findings from the optometrist by the client / patient.	3.00	1.12	3.14	0.38	3.22	0.83
I do think there is a need for a referral for an optometric examination and a receiving a diagnosis and management rapport	3.08	0.51	3.29	0.49	2.33	0.71
For my clients / patients is a need to receive clear recommendations in relation to the treatment of DED and adaptation of the workplace*	3.33	1.23	2.86	1.35	2.56	1.14
There exists a need for recommendations with respect to the severity of the (work-related), DED that can be included in the plan of action	3.25	0.62	3.29	0.76	2.11	1.27
With eye-related complaints, there is a need of clients / patients to receive the clinical findings (explanation plan) of the GP	3.08	0.51	2.71	0.76	3.44	0.53
Role in care model						
My role in a possible care model will best be on diagnosis and treatment.	3.58	0.51	1.71	0.76	3.44	0.53
My role in a possible care model will best be on prevention and referral.	2.33	0.65	3.14	0.69	1.89	0.60
Kendall's W	0.496		0.258		0.457	

7.14 Who will be or can be the specialist in primary dry eye care?

The optometrists strongly believed that they could be the leading professional in DED management, that this should be based in primary healthcare, with the possibility of working in a multi-disciplinary team with GPs and ophthalmologists, and that they should be the lead professional for DED management.

The OHPs strongly believed that DED care should be diagnosed and managed in primary healthcare, and that the optometrist could play a leading role. They had some concern about the level of knowledge of the GPs and the optometrists, as they felt that they (OHPs) do not know exactly what the knowledge should be.

The GPs believed that there was no specific leading role for a professional in dry eye care in primary healthcare, but that the optometrist could play a role in the management of DED in collaboration with GPs. They had concerns about the professionalism of the optometrist, regarding their possible conflict between patient care and commerce, and that the treatment of dry eye should be seen as a normal aging process rather than as a disease. The role of the optometrist as the lead professional was not unanimous, but they did see a role for optometrists in primary healthcare

7.15 Wishes and needs, open question

7.15.1 Optometrists

The open question, asking about their needs and wishes, showed a consensus of >75% (Table 7-1), and the answers could be coded into 4 sub-categories: multi-discipline/inter-discipline, extended-tasks and responsibilities, health insurance, and knowledge.

For the multi-discipline/inter-discipline category, the optometrists agreed that there is a need for better contact with the GP through a good communication platform, and that the GP is essential as the main primary healthcare provider.

Nevertheless, the optometrist would like to see more understanding by GPs about their abilities and capabilities in optometric diagnostic and management skills. The optometrists specify the need to place dry eye care in primary healthcare as a transfer-over from ophthalmology to the optometrist, as they see dry eye care management as part of the core competencies of the optometrist. They feel that this care should be covered by health insurance, possibly using the ICD code for dry eye-related problems. By undertaking the responsibility for dry eye management, optometrists felt it would be necessary to adopt a quality assurance system to ensure the optometrist can be identified as a specialist, e.g. yearly CE/CPD, bench-marking, and an expansion of possible treatment options by optometrists.

7.15.2 OHPs

The wishes and needs questions showed a consensus of >75% (Table 7-1). There was a high consensus on the need for an optometric report to the OHP on any examination, and on the need for recommendations, with respect to the severity of the (work-related) DED, that can be included in the plan of action. The OHPs wishes and needs, open question, could be coded under two sub-categories: knowledge and care system.

The OHPs expressed their wish for more knowledge on the specific treatment options available to enhance their advising skills. They felt that the treatment options given by ophthalmologists are too narrow, and that there is a need for more knowledge about the indoor environment and dry eye care, and of other aspects of work-related dry eye, as it is too limited at the moment. They wanted more opportunities to gain knowledge and expertise in this topic, and the knowledge to be able to judge the appropriateness of a treatment.

For the care system, in their opinion, the GP should act as the primary care provider, but this task could be given to a specialist optometrist. Work-related factors need to be addressed by the OHP. The care system should have the current structure, with a well-educated professional dealing with dry eye care, giving easy access for consultation. As one OHP quoted: "*There is no need to*

create a new niche market". Nevertheless, a specialist is needed to give the complete treatment options and advice. Another OHP felt that the GP and OHP are already acting in primary healthcare, so there is no need to create a new care system, although a specialist is needed who can be asked about specific problems. There is a need for guidelines on who to ask for a specific problem. This should also be known by computer-work consultants and ergonomists, to make sure that the correct treatment will be offered by them.

7.15.3 GPs

The GPs showed a consensus of >75% (Table 7-1) to the wishes and needs question. Overall, they were less positive than the optometrist and OHP on the need for an optometric report from any examination, and on the need for recommendations with respect to the severity of the (work-related) DED that can be included in the plan of action. The reactions of the GPs could be coded into 2 sub-categories: care model and knowledge.

For the care model, one GP said *"In my opinion a paid specialist is more than welcome"*, and another said *"A specialised (a good) optometrist in primary healthcare is, to my mind, a need"*. However, more generally, GPs were critical of a specialised dry eye professional: *"There needs to be a place in the care system for the GP performing slit-lamp examinations too, and think about being pragmatic about care, as the care given by a GP can be as successful as the investigation and treatment by an ophthalmologist"*. About the specialised role in the care system: *"No argument needed to get a 'head-leader' for dry eye care - care needs to be done, and properly done, by a professional"*. Another GP shared this comment: *"Think about patient-centered care, the patients will choose the care provider, and all, the GP, optometrist and ophthalmologist, could have the proper attention and care for this problem"*. One GP stated that communication in the care system should be focused on local (regional) arrangements and engagements between the professionals.

For the second category (knowledge), the needs were to promote a good, accredited, dry eye course for GPs (ca. 5 hrs) to address DED problems, as

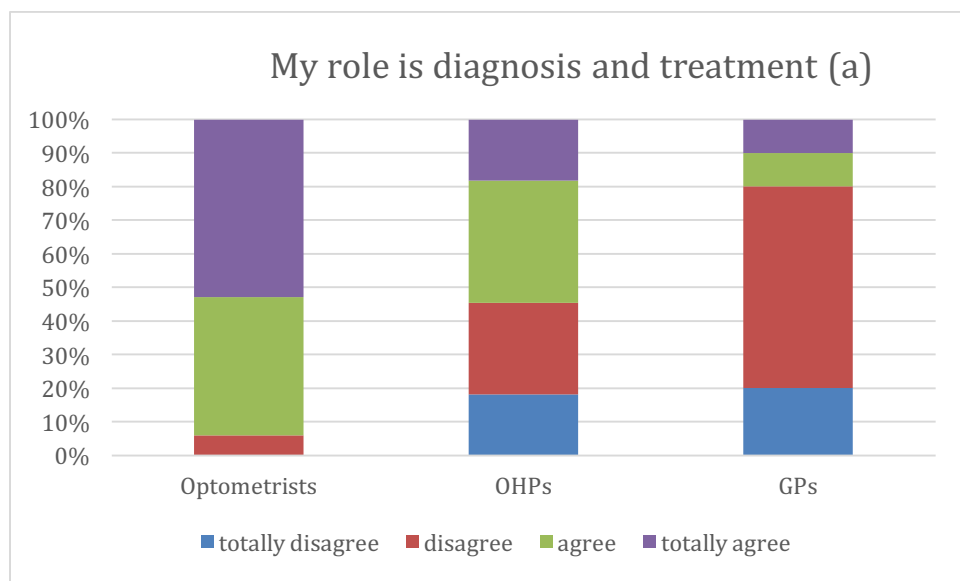
there is almost no ophthalmology CE available on this subject, especially for certified GPs who follow CE.

7.16 Professional role in a care system

The optometrists showed a consensus (80% fully agreed and 20% agreed) that DED is within optometric care. The OHPs were almost split between agreement and non-agreement. Of the GPs, only 20% saw DED as being within optometric care. The GPs see dry eye care in primary healthcare, but not specifically linked to one professional, in this case the optometrist.

When each panel group was asked to look at the role they think they should fulfill in a new care system, 2 questions were asked: 1) My role in a possible care model will best be in diagnosis and treatment; 2) My role in a possible care model will best be in prevention and referral (Figure 7-6).

Looking at the answers given, the optometrists see their role in diagnosis and treatment, with a mixed, but more negative, response to the prevention and referral role. The OHPs see themselves in prevention and referral, and less so in diagnosis and treatment. The GPs had no consensus on whether they see themselves in prevention and referral or in diagnosis and treatment.



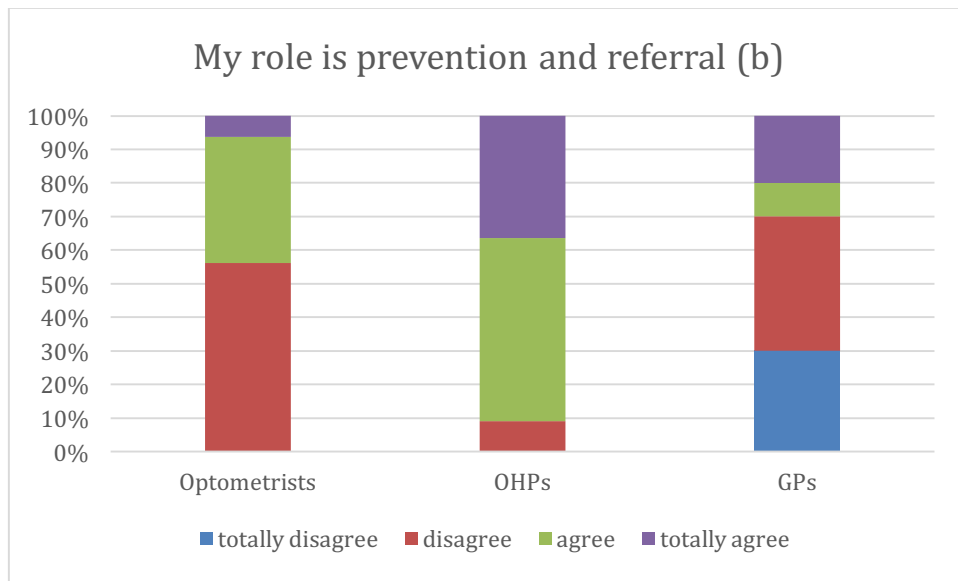


Figure 7-6 Professionals answer to their role in healthcare

Answers to the questions: (a) My role in a possible care model will best be in diagnosis and treatment; and (b) My role in a possible care model will best be on prevention and referral”, for each healthcare professional group (%).

7.17 Concluding Delphi Round 1

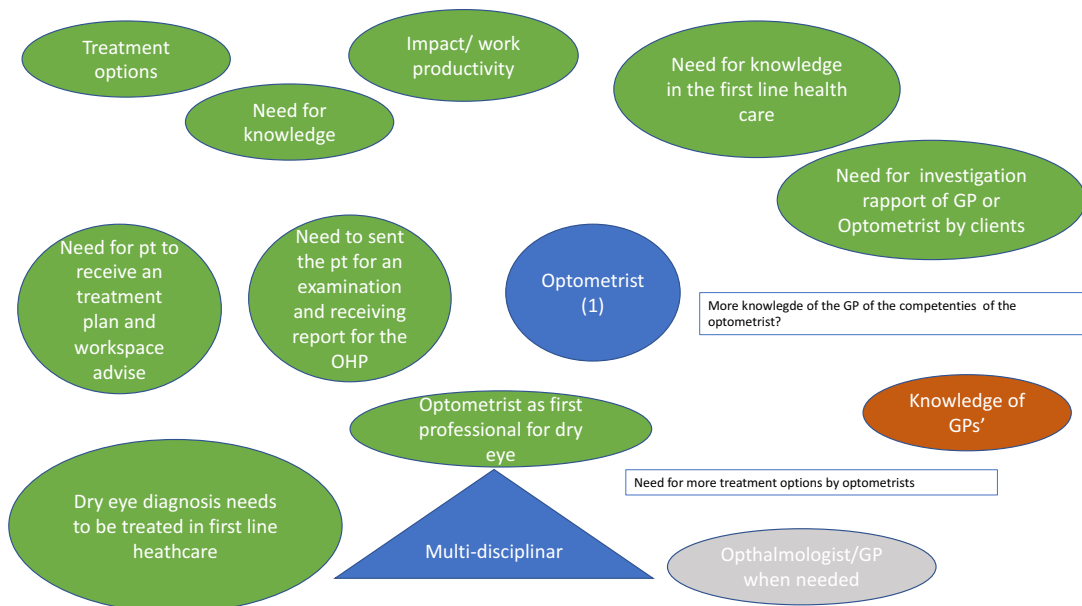


Figure 7-7 Agreement at optometrist panel

Optometrists: Questions with full agreement are coloured in green, and those with areas of low consensus are grey and brown. Grey represent the question of whether the optometrist should be the lead professional.

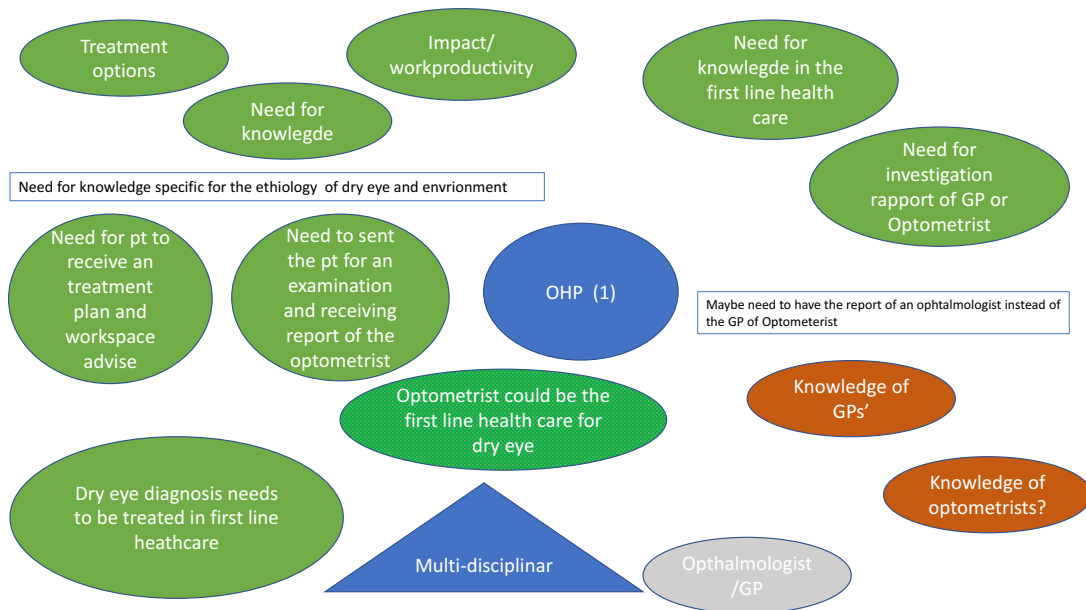


Figure 7-8 Agreement at OHPs panel

Questions with full agreement are coloured in green, and those with areas of low consensus are in brown and grey, blue represents the question of whether the optometrist could be the lead professional.

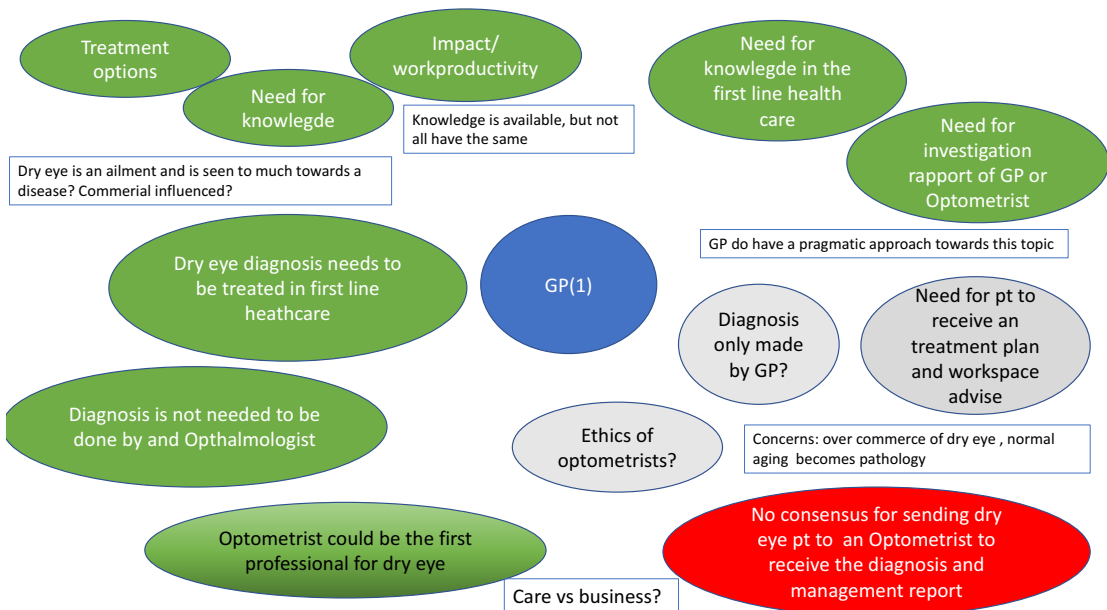


Figure 7-9 Agreement at GPs panel

Questions with full agreement are coloured in green, and those with areas of low consensus are in grey, and those with no consensus in red.

7.18 Delphi Round 2

The optometrist and OHP panels showed a similar outcome in Round 1: questioning the knowledge of the GPs to diagnose and manage DED, and doubting whether the care system currently sees and should see the

optometrist as the leading professional in DED care, with different focus points on responsibility.

7.18.1 Optometrists and OHPs opinion: Position of optometrists in primary care

The position of the optometrist in primary healthcare had a positive consensus, but there was a preference for specialised dry eye care by both the optometrist and OHP panels. They agreed that the optometrist should not have to work under the supervision of an ophthalmologist.

7.18.2 Optometrists and OHPs opinion: Optometrists leading in management

A specialised optometrist, with a range of management options, including the prescription of drops, treatment of MGD and blepharitis, insertion of punctum plugs, prescription of spectacles, bandage lenses or scleral lenses, was seen by the optometrists and OHPs as being complementary in a triangle of care, between GP, OHP and optometrist.

The OHP panel *mostly* agreed with the statement that the optometrist would be placed in the triangle of primary care; two of the panel did not agree, and others made some additional comments reflecting their feeling that the connection to the work situation needs to be addressed more in the management options. Two comments related to the difficulties they have in understanding the management options given and in seeing the relevance of these management options. One concluding comment was that the knowledge to perform those management options must be excellent to avoid over-treating individuals.

The optometrists agreed 100% that this specialist optometrist would complement primary healthcare, although one optometrist replied that, *“Personally, the management options, such as punctum plugs or scleral lenses, were not their main interest, and not all optometrists need to be specialised in therapeutic lenses”*.

Five optometrists reported that they felt capable of using punctum plugs and MGD treatment in their scope of practice, but that some CE was necessary.

7.19 Optometrists and OHPs opinion: Knowledge of DED

The optometrist and the OHPs agreed on the need for gaining more knowledge about the influence and impact of the environment, especially the work environment, and the effect of using electronic devices on the development of dry eye.

7.20 Optometrist and OHP opinion: Optometric skills

The optometrist panel agreed that an optometric, dry eye-related, examination should include investigation of possible asthenopia complaints, and the OHP panel agreed that they think it must be part of a dry eye examination.

7.20.1 Optometrists opinion: New healthcare pathway

The optometrist panel agreed that they are capable of managing the treatment options, but there were some concerns about the role of the optometrist as a care profession in primary healthcare. The proposed arrangement of healthcare in the Kaljouw Report (2015)²⁰⁴ was not known by the optometrists, although one optometrist had heard about the report, and one said that they read some of it.

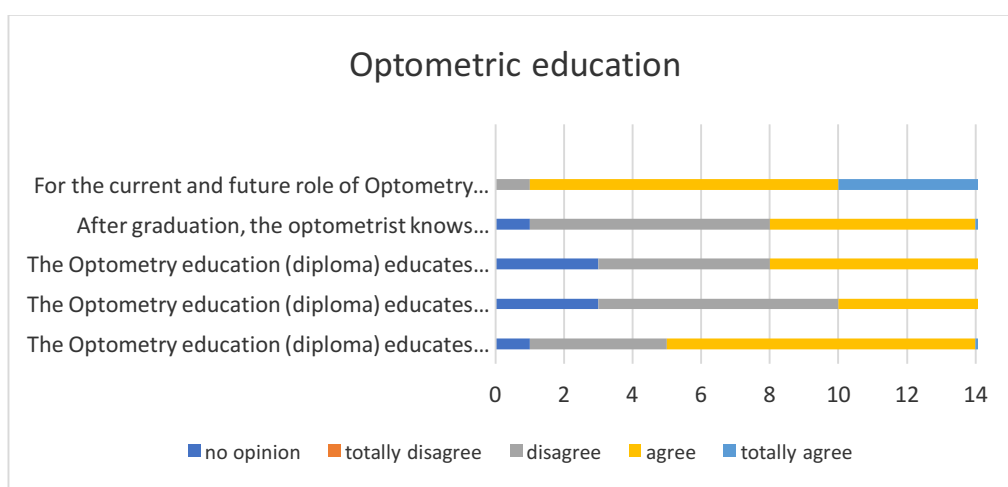


Figure 7-10 Opinion of optometrists about optometry education and the role and knowledge of the optometrist in general healthcare.

This limited knowledge was reflected by the fact that the optometrists had no consensus about the knowledge given to students to understand their role in healthcare, or about the education given to students about the concept of healthcare in general (Figure 7-10). There was a more positive opinion that current education does teach about acting as an independent eye care professional.

7.20.2 Optometrists opinion: Wishes and needs of optometrists

The optometrists expressed their desire (Figure 7-11) to be seen as the eye care professional in primary care.

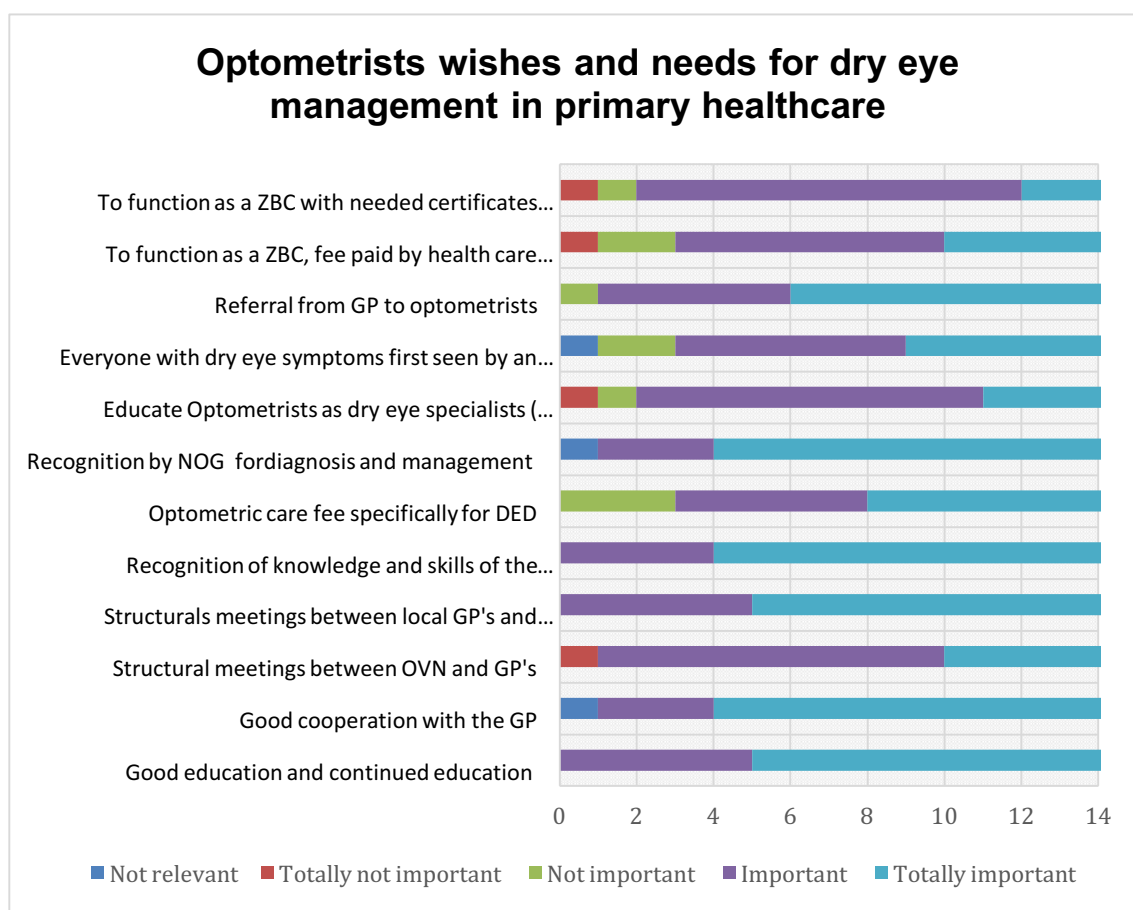


Figure 7-11 Optometrists wishes and needs for dry eye management in primary healthcare;

NOG: Nederlands Oogartsen Genootschap; Dutch Ophthalmology society; ZBC: zelfstandig behandel centrum (independent treatment centre).

These wishes and needs could be categorised as: financial independence, recognition as a primary eye care professional by GPs and ophthalmologists, structured inter-disciplinary communication, and specialist education.

7.20.3 OHPs opinion: Position of optometrists in primary care

The OHP panel reached consensus with the statements that: there is a need for a specialist who can make clear what the underlying problem is (diagnosis) and that: the possible treatments (also translated into environmental issues so that it can be included in the consultation) should result in customised advice. It was felt that the treatment options and knowledge regarding indoor climate and other relevant work-related aspects offered by ophthalmologists is too narrow. The dry eye specialist/optometrist should work in primary healthcare as a dry eye specialist, with insured care, and should be capable of managing dry eye symptoms, and, importantly, be embedded in the existing (eye) healthcare system, not a newly created niche. The OHPs agreed that the optometrist should not have to work under the supervision of an ophthalmologist.

7.20.4 OHPs and GPs opinion: Optometrists as a supplement in primary healthcare

In answering the statement: The work of the graduate optometrist, as described, is seen as a supplement in primary healthcare, both OHPs and GPs were supportive, but the OHPs answered more positively than the GPs, with an 81% consensus, compared to 64% for the GPs.

7.20.5 GPs opinion: A specialised optometrist is complementary

More than 80% of the GPs agreed that a specialised optometrist would complement dry eye care in primary healthcare. There were two remarks: *“It is a small (though not always important) area of concern for which input is welcome, although the bulk of the dry eye symptoms can be treated by the GP. There is a lot of expertise with optometrists, when they are working independently from commercial entities, I see a lot of opportunities.*

Many GPs seems to have little affinity for ophthalmic problems. But therapy-resistant patients, such as Sjogrens’ disease patients, can be best treated by an ophthalmologist, thinking of specific treatment like cyclosporine drops”.

7.20.6 GPs opinion: Optometrist as DED specialist

Of the GPs, only 1 out of 10 felt that a DED specialist could be complementary to primary healthcare, with the intention that all dry eye patients not related to Sjogren's Syndrome could be seen by GPs. However, another panel member said that although it is a small part of healthcare, it is important, and it is welcome to have every extra input for this care.

7.20.7 GPs opinion: Care system and specialism

To the question: When an optometrist is recognised as someone with additional training (post-HBO Master Level) for dry eye problems, like the optometrist with additional training for glaucoma or macular degeneration, I see this person as still working in primary care, all GPs answered positively, with one remark: "*How will the optometrist be recognisable with this kind of additional training?*".

This is in-line with the answers given to the statement: DED should not be commercialised, the optometrist as a primary care professional will have to show that they work and act as a "health professional". All GPs answered this question positively as either 'agree' or 'totally agree'.

There was also consensus between GPs on agreeing to the following statement: For ophthalmological complaints, proper arrangements between local GPs and optometrists is important, in their region, to know what each one does and can do.

In the first Delphi round for GPs, there was a strong opinion of not creating another professional or specialist in the primary healthcare, and they strongly rejected the creation of a "niche" in healthcare.

7.20.8 GPs opinion: Need for a care coach

To the question: In primary healthcare, is there a need for a new care coach for eye-related problems?, the GPs were almost evenly split between agreeing and not agreeing on the need for a new professional in primary healthcare, as one GP said: "*In the primary healthcare, I think the GP should take this role more,*

but, if not, an optometrist can do the job, wisely, not as an optician”, and another said: “Care coaches are too exorbitant for this (minor) problem”.

About treatment options given by the ophthalmologist, the GPs were asked to answer the following statement; Right now, for me, the management options offered by the ophthalmologists are too narrow. The answers on this question showed no consensus, with just over 50% in agreement.

7.20.9 GPs opinion: Competency of optometrist for ABCD model

The GPs showed a positive response towards signaling, preventing and monitoring, although a consensus was only found for signaling and monitoring. The responses for the public health-related topics, such as promoting health, preventing disease and protecting health, showed a mean of 3.00 (Likert scale), but no consensus was reached (Figures 7-12 and 7-13).

7.21 Delphi Round 3

7.21.1 Optometrists and OHPs opinion: Competency of optometrist for ABCD model

For the optometrists, consensus was reached that the optometrist has the competencies regarding primary care and public health, as mentioned in the Kaljouw Report. The OHPs showed a consensus only on competence signaling (Figures 7-12 and 7-13). Half of the OHPs reported finding it difficult to answer this question since they lacked knowledge about the competencies of the optometrist.

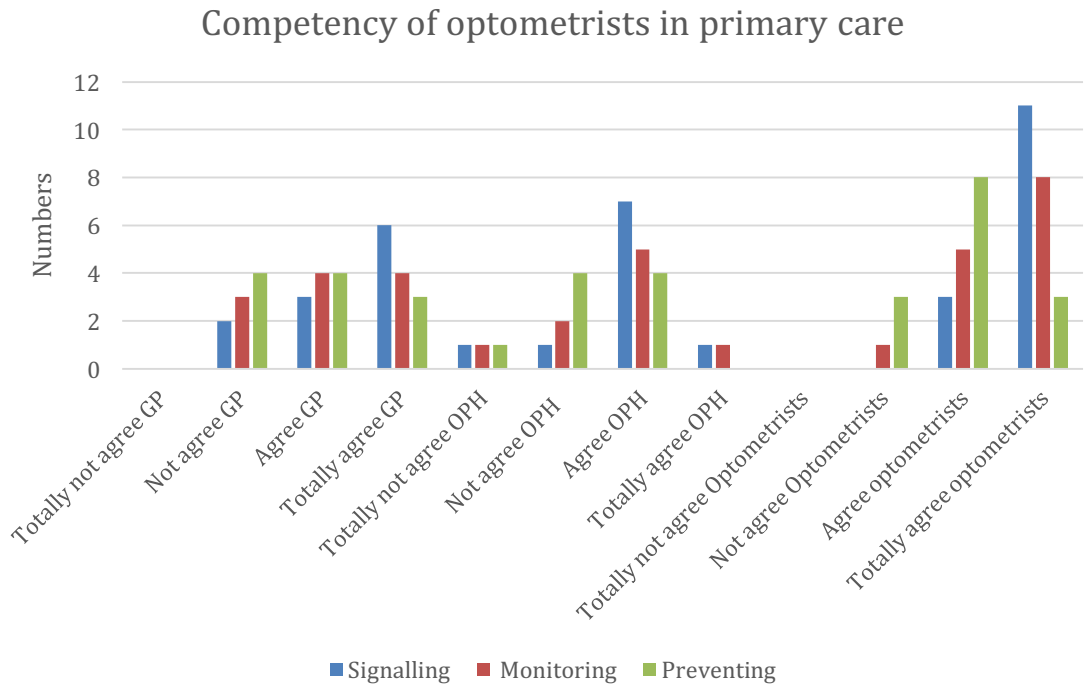


Figure 7-12: Each profession’s opinion on Competency of optometrists in primary care.

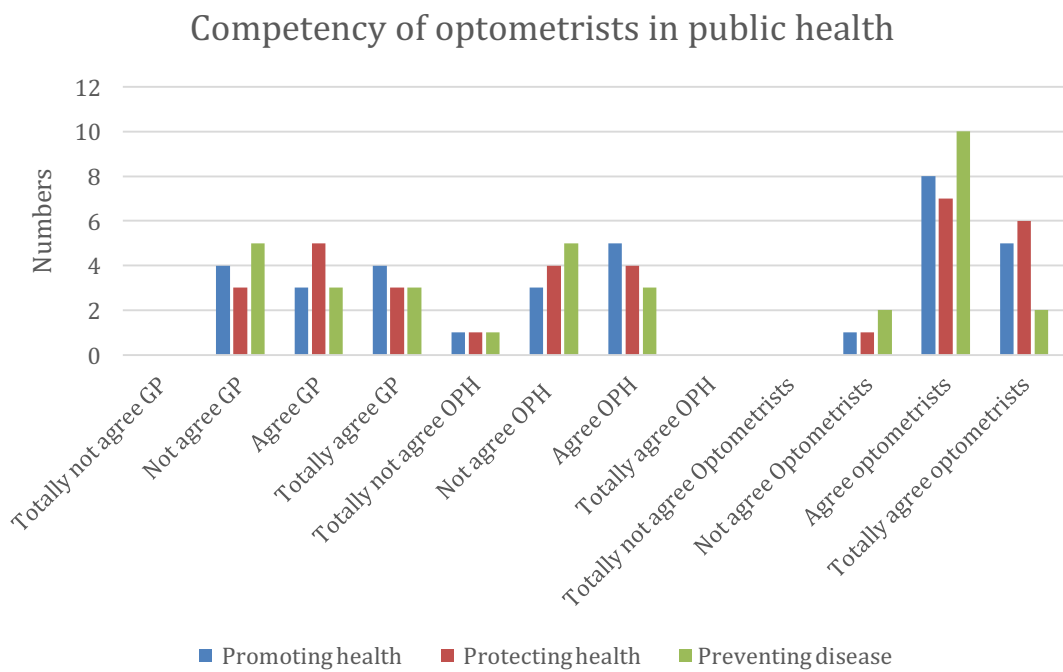


Figure 7-13: Each profession’s opinion on Competency of optometrists in public health

7.22 Delphi Round 3 Optometrists

7.22.1 Optometrist opinion: Scope of practice of optometry and competencies

To further explore the meaning of the optometrists' competencies, 2 questions were asked to discover the optometrists' opinion on the extent of their scope of practice.

There was a positive consensus that an optometrist could be recognised as someone with additional training (at the post-graduate Masters level) for dry eye problems, just like an optometrist with additional training in glaucoma or macular degeneration management, and that this optometrist would work in primary healthcare. The priority should be in creating local agreements between GPs and optometrists for ophthalmic complaints.

7.22.2 Optometrists opinion: Innovative

Do you think that Optometrists, in general, are innovative towards care, such as creating local appointments with general practitioners? Four of the 14 optometrists were in total agreement, with the remainder also supportive, but less so.

The disagreeing optometrists had the concern that while the optometrist could be the professional to create local meetings with GPs, the difficulties between the different scopes of practice for optometrists, working as either an independent healthcare professional or in a chain optical store, could make it difficult to act as a united group. There is a lack of knowledge of how other professionals are doing this, and not enough consensus about the scope of practice of the delivery of care by optometrists. It is still an unknown, "young" profession, and optometrists are not seen as active in creating awareness about optometry or in creating a role in primary care.

7.22.3 Optometrists opinion: Skills and care

In answer to the question of whether the optometrists felt that they have sufficient skills (from optometric education, CE training, OVN communication,

or by other ways) to know the rights and obligations of a healthcare professional, 12 optometrists felt that although they had some knowledge, they doubted whether it is enough to answer this positively, as they lack knowledge about insurance policies and government regulations, in general, and whether optometric care is covered by health insurance, in particular. It was generally not recognised as a topic covered in detail in the optometry curriculum at the University of Applied Sciences, Utrecht.

7.22.4 Optometrists opinion: Conclusions on the ideal situation

The question was asked: What if, next year, there is a remuneration system, similar to that for the physiotherapist, for optometric care. Specify what will change for you and for your practice?

The answers from the optometrists could be coded as healthcare-related: accessibility, referrals by GPs, prevention, independency, and concerns. When covered by insurance, they felt that the accessibility to optometric eye care by the public will increase tremendously. They believe that GPs will refer more patients to the optometrist and that they would perform more prevention-based eye examinations than problem-based examinations. Some professional insecurity was mentioned regarding awareness of the care pathways, insurance policies and government regulations, that would hinder their ability to contribute to a local multi-disciplinary care system.

7.23 Delphi Round 3 OHP

7.23.1 OHPs opinion: Needed communication between OHP and optometrist

For the OHPs, the first Round 3 question focused on communication between optometrists and OHPs, as the GPs mentioned this as a priority in Round 2. The reaction was highly positive, that an arrangement for communication in a region between OHPs and optometrists for eye-related problems is a priority, with the focus on mutual-learning about the scope of practice of both professions. The added comments were of the need to know competencies, the need for proper guidelines for referral, and a need for a good financial system.

7.23.2 OHPs opinion: Conclusions on the ideal situation

The summary statement from the previous two rounds indicated that receiving a report about the eye exam, and possibly optometric advice, was seen as bringing value, but that the management decision based on the advice should be made by the OHP.

The OHPs expect clear answers to an (eye) care question by the optometrist; that communication about the advice from the optometrist should only be carried out after consultation with the OHP; that optometrists should be identifiable for any referral and should be accessible for any eye-related advice, that a remuneration system for an optometric examination should be paid for by insurance; and that, in the near future, an initial consultation between the OHP national professional board and the OVN (Optometrists Association Netherlands) is necessary, in order to develop guidelines.

The responses to these summaries were positive, except on the communication of advice given by optometrists, which was seen as a major item. The OHPs felt that it was not practical or useful for the client, as they have the final responsibility. Communication with the optometrist is essential, and new guidelines are needed with specific tasks and responsibilities for the optometrist towards the OHP. There is a need for more knowledge of the competences of optometrists and for practical guidelines. The payment of the optometric examination was seen as a major item in the professional communication.

7.24 Delphi round 3 GPs

7.24.1 GPs opinion: Conclusions on the ideal situation

From the previous round, the role of the optometrist and their added value in primary healthcare produced very different reactions in the GPs. Consequently, the GPs were asked to write down their ideal situation of the relationship between GPs and optometrists. The answers given could be coded under the sub-categories of: referral, relevance, optometrist core business, communication, concerns, and tele-medicine.

There is a need for receiving patient information from the optometrist in a similar form to that from other paramedical professionals, such as the physiotherapist who can be consulted directly without a referral by a GP. The optometrist could be the professional in primary eye care if the GP does not have a certificate in advanced eye care. If the optometrist is the professional provider in primary care, the patient consultation should be covered by healthcare insurance to avoid a commercial conflict when working in an optical store. The referral advice to an ophthalmologist by an optometrist should still be made through the GP.

7.25 Discussion

This investigation is beginning the process of building a care pathway or care system for DED patients, and it considers the needs, wishes, attitudes and willingness of three key, primary care, healthcare professionals, who would all be part of a DED care pathway. While the GP plays the central role in primary healthcare, optometry has a big role to play in eye care, and especially in the care of DED, and their function will fall under 'pre-care' and 'low complex care' in the planned new Dutch healthcare system. The OHPs will have a role in prevention, functioning and participation.

It is important to consider the findings from this study within the context of the current healthcare system in the Netherlands. Primary healthcare in the Netherlands is facing big challenges regarding the scope of practice, competencies required, and the role of the professionals themselves as it changes to the ABCD model.²⁰⁴ The move towards patient-centred care will require new competencies from healthcare professionals.

The Inter-professional Education Collaborative (IPEC) has described 4 transcending competencies for all healthcare professionals: 1) Values/Ethics for Inter-professional Practice, 2) Roles/Responsibilities, 3) Inter-professional Communication, and 4) Teams and Teamwork.¹³⁴

7.25.1 Values/Ethics for Inter-professional Practice

Each professional is expected to have the necessary skills to take responsibility for the areas assigned to them, whether that is in prevention, diagnosing or management. In this study, the role of the optometrist as the lead professional in a dry eye pathway was proposed, but the current values and ethics of optometrists for inter-professional practice were questioned by the GPs and OHPs. Partly this was from a lack of knowledge about the competencies of optometrists, and partly from ethical concerns about the commercial aspects of optometric practice impinging on optometric decision-making. The lack of recognition for optometry in primary healthcare by the government health insurance system was felt to be a barrier to removing the financial issue, as it was felt that GPs and OHPs were reluctant to refer to optometrists, knowing that the patient would have to pay for the consultation. A similar problem has also been seen in a study of task substitution in glaucoma care.²⁰⁹

However, a change in health insurance status for optometrist would have benefits, not just for dry eye detection or management, but it would also increase the number of patients seeking help for general eye care issues. For example, the introduction of the Wales Eye Care Services (WECS) has been responsible for an increase in the number of examinations, leading to earlier help for low vision patients, and less visual disability among patients.^{210,211}

Although the current OVN ethical code of conduct could be better publicised amongst GPs and OHPs, this study has confirmed that optometry has not yet secured a clear role in primary healthcare.

7.25.2 Roles/Responsibilities

The GPs think that the scope of practice of optometrists consists mainly in signaling and monitoring diseases, and that the optometrist is not recognisable as a care provider with a wide scope of practice. For patient-centered care, the optometrist needs to become more inter-professional, and not only with other eye care professionals.

In particular, there is an opportunity for optometrists to replace ophthalmologists for some GP eye care referrals.¹¹⁹ Nivel et al. (2012)¹¹⁹ reported that the optometrist could prevent 85% of GP referrals to an ophthalmologist.

Hassel et al. (2013)¹¹⁸ calculated that 207,000 patients could be seen by an optometrist instead of the GP. Although the GP was seen as the first caregiver for DED symptoms, with referral to the optometrist,¹¹⁸ this is in contrast with the findings in Study 4 and this investigation, which found that the GP sees that the optometrist can play a role as a “specialist” in dry eye management.

Not taken into account in these calculations were the patients in secondary healthcare, or the under-diagnosed DED patients who are using ‘over the counter’ pharmaceutical products, suggesting that the impact could be even more significant.

Interestingly, one objective in the NOG (Dutch ophthalmologists association) strategic and operational objectives (2017-2019)²¹² is to be the leader in task re-distribution in eye care. They estimate that task re-distribution of eye care from the ophthalmologist to an optometrist was estimated to be low. It was proposed that the development of DED referral pathways from primary care to secondary care should be a priority, as has already been done for glaucoma.²¹³

Task re-distribution raises difficulties in finding or creating an acceptable funding model, especially if optometrists are working across primary, secondary and tertiary healthcare, since the funding is allocated within each healthcare level. Shickle (2014) addressed the need of good funding to enhanced the optometric care.²¹⁴ They argued that the separation of care and commercial activities is needed to permit enhanced optometric care, as the sale of optical appliances is currently needed to cover the costs of eye examination. Screening of patients to avoid loss of vision can only be preventative when the care is accessible without any possible commercial conflict.

7.25.3 Inter-professional recognition and communication

There is a need and place for optometry in primary care,^{215,216,217} and although there is not a referral pathway from primary care to ophthalmology for DED, the core competences of the Dutch optometrist makes them able to diagnose and manage DED. Even so, optometrists feel that further training as a specialist in dry eye care is needed. Interestingly, Stevens et al. (2007) showed that inter-professional recognition was rated higher by optometrists who called themselves 'specialised optometrists'.¹³³ Furthermore, recognised specialist training would help to create better inter-professional cooperation by reassuring other healthcare professionals of the specialist's competencies.

Although it was not the focus of this research to look at the knowledge and attitude towards the scope of practice of optometrists, the optometrists believe that further education, at the Masters level, is needed to enable them to become the leading primary care specialists for DED.

For a successful chronic care model, 10 characteristics were described by Ham et al. (2010).¹²⁹ One of these is the use of an electronic patient record to enhance communication between healthcare professionals, with the aim of reducing possible errors of care.¹²⁹ The development of an electronic file system is key to assisting healthcare professionals in contacting (or referring) to each other directly. All of the professional panels in the survey agreed on the need for a referral/contacting system. For the GPs, this system would allow them to make the final call for referrals to ophthalmology easier. The clinical decision support that an electronic system can give will enhance the relationship between professionals.¹²⁹

In diabetic care, the use of the chronic care model has increased the quality of care delivered in primary care.²¹⁸ The diabetic model is common in the Netherlands, with the diabetic nurse, GP and optometrist working together to read patient fundus photographs.¹²⁴ The GP is the co-ordinator of the diabetic scheme. However, no direct communication commonly occurs between the diabetic nurse and the optometrist or GP, and there is no inter-disciplinary education given at the University of Applied Sciences in Utrecht, even though

the education for diabetic nurse and optometry occurs in the same building. This again emphasises the important message that inter-disciplinary education is needed to enhance patient care.

7.25.4 Competency team and teamwork; Professional insecurity

One of the core competencies for Inter-professional Collaborative Practice written by IPEC in 2011, and adjusted in 2016, is: *to use the knowledge of one's own role and those of other professions to appropriately assess and address the health care needs of patients and to promote and advance the health of populations.*¹³⁴

For the creation of new (local) care pathways, communication is the essential key to get started. It is said that inter-professional collaborative practice (IPCP) can only occur when the healthcare professionals involved are educated in inter-professional education, public health, and health policy.²¹⁹ To meet the criteria towards a patient-centered care, communication competences need to be addressed. It is noted that inter-professional collaboration needs to be learned.^{219,220}

The team and team work competency applies to relationship-building values and the principles of team dynamics. Relationship-building is needed to remove insecurity towards other healthcare professionals. In particular, this was directed by the GPs and OHPs towards the optometrists. This could be due to a lack of knowledge about each other's competencies, which could create a barrier toward changes in the care pathways. It is important to recognise, and respect, the scope of practice of other healthcare professionals, and to know their core competences. This will result in a lessening of the attitude by professionals to control their own domain. This emphasises the need for inter-disciplinary education to encourage collaboration.

The GPs, optometrists and OHPs believe that the current primary healthcare system would benefit from better inter-professional communication and co-management of patients. The OHPs felt that prevention should be part of DED

management and that the chronic care model can be the blueprint for improving prevention. However, mutual ignorance about scopes of practice, the lack of recognition of the optometrist as a care provider, and the inadequate coverage of the optometric fee by insurance, are all factors limiting progress.

7.26 Limits

While the Delphi method shows only the opinions of a minority of a healthcare profession, nevertheless the consensus in each panel by Round 3 showed that each group was representative of the same issues and concerns.

The opinion of the optometric panel should possibly be interpreted more carefully, since some panel members withdrew early on, as they felt they were not involved with care systems and the recent developments in healthcare. Their input could have led to a better understanding of the diversity in optometrists working in primary care.

The diversity among the GPs, from not being involved in eye examinations to working fully-equipped, benefited this investigation, and this diversity in the scope of practice and knowledge should be further investigated.

Other limits in this investigation is the lack of focus on prevention, self-management and public information given by the professionals. The questions are asked if they do think they are capable but not who they are performing these tasks, as differences can occur in the perception what is needed for these patients. In the believe of the author a focus towards self-management, public information and prevention options were beyond the aim of this investigation and would be a topic for an investigation on its own. Although strong and robust evidence is lacking in this field, no RCT is done by the author knowledge in the field of self-management and prevention for DED. Whilst the evidence known, is confusing towards the management options given and the best therapy by the condition as the management in clinical practice seems to be best individual based. Research is needed to answer these questions as described above.

For development of inter-professional and inter-disciplinary guidelines, a criticism could be that the study did not attempt to organise a central meeting to harmonise the opinions given by panel members. However, the consensus per panel was high and the concerns and needs were interchangeable between the panel members.

7.27 Recommendations

GPs, OHPs and optometrists are all needed to take care of DED and occupation-related dry eye. The professional responsibility for (dry) eye care and management was seen as a task for the optometrists by the GPs, OHPs and optometrists.

Research need to be promoted to self-management, prevention and public information by (eye) care professionals, work related dry eye could be a topic to investigate using a long standing RCT by, for example, office workers.

Better education about collaborative, inter-professional practice is needed to answer the care needs of the patient, and to enable an individualised approach to patient-centred care. This needs to start with inter-professional and inter-disciplinary education for DED. A development of a chronic care model will only succeed when the professionals can work collaboratively together. Long et al. (2014) provided an event for optometrists and ergonomists to meet each other, to improve patient/client visual out-comes in the workplace. Both professionals felt the need of better communication between their respective profession in regard to tasks and assessments, and to improve patient care.¹³¹

The economic benefits should be investigated for a longer period of time, as next to consultation time (patients and between professionals) and costs of given treatment other factors needs to be investigated as well like illness perception, work productivity and quality of life in a RCT.

The professional bodies were seen as the leading force in developing guidelines, but that regional and national meetings would help in promoting inter-professional communication. A future plenary meeting could be the first

step towards a change in inter-professional work ethics. The group should be at the professional board level.

Change optometric education to promote inter-disciplinary practice, to educate about the health system and to encourage optometrists to become pro-active, innovative, care professionals. The development of guidelines by experienced professionals needs to be incorporated into evidence-based practice in education.

7.28 Conclusion

This Delphi method has revealed the differing views of GPs, OHPs and optometrists towards DED care, skills, knowledge and care systems. The positive attitude of all panel members towards inter-disciplinary eye care for DED is promising, but the inter-professional collaboration needed for patient-centred care in a chronic care model needs stronger inter-professional education. A DED certified optometrist will have a role in inter-professional management in primary care.

8 General Discussion

This thesis had two overall aims: 1) investigate the need for a change in the primary healthcare system for mild-severe dry eye in the working age population in the Netherlands, who are working in office buildings with highly-demanding visual tasks, and 2) to consider what kind of care system would be most suitable, in order to enhance patient care. The studies undertaken have produced a series of conclusions, and provided several recommendations for future work.

8.1 Office-related dry eye

Study 1 demonstrated a diagnosed dry eye prevalence of over 30% at the 3 test locations chosen. For Location 3 (the location used for further investigation in Studies 2 and 3), an even higher percentage of 47% for diagnosed dry eye was found in the under 60 years age group. This is a significant increase over the percentage of dry eye found in a comparable age group in the general public of 14.5%²²¹ or 19.5%.²²² Although there is evidence that DED is a real and significant issue for office workers, more research is needed to work related DED and an age matched control group to compare the possible influences of age vs work environment.

Studies 2 and 3 showed that participants felt their workplace environment to be a significant influence on developing eye discomfort or DED. Forty-four percent (44.1%) of office workers blamed the indoor climate as the main reason for their developing dry eye symptoms. They experienced significantly more eye symptoms at work than at home, such as stinging, burning and itching of the eyes. They also reported a negative impact from DED on the function of daily activities in the office environment – more than two-thirds of participants experienced some inhibition in their daily work activities from eye symptoms, with over 5% experiencing symptoms most or all of the time. The participants described a number of different factors responsible for their symptoms, but they felt that the indoor climate had the most impact, with general health ranked second, work environment, third, and reading and computer-use, fourth.

Study 3 showed a negative social impact from the dry eye discomfort symptoms in these office workers, especially in those individuals with higher OSDI scores – a group that included a large number of diagnosed, dry eye patients. These workers reported a reduction in their quality of life and in the ease of visual-demanding tasks away from work, e.g. reading, driving, etc., which correlated with DED severity.

Although there were some gender discrepancies, females with or without DED experienced more inhibition in their daily activities from eye symptoms than males. This was confirmed with the Work Productivity and Activity Index (WPAI) and the Illness Perception Questionnaire (IPQ) (Appendix 2: WPAI and Appendix 3: IPQ), which were both more negatively reported by females. This matches with the literature, where there are reports that females experience more SBS symptoms and a greater negative impact on work productivity.^{139,146}

Many workers felt that there was limited benefit from their current treatment regimens, as shown by the answered question of the Illness Perception Questionnaire in this investigation. There was some discrepancy between the dry eye treatment used and the severity of the symptoms, with individuals with a normal OSDI score using artificial tears and individuals with severe OSDI not use any treatment at all. Some concerns can also be raised around the use of alternative treatments, as contact lens solutions, tap water and others.

In Study 2, the outcome of the indoor air quality analysis showed a low relative humidity in the office and a high air draft, combined with a higher CO₂ level, all in a building categorised as being “acceptable” under the NEN-ISO-7730:2005 code. However, the high visual demands when using the computer, and the influence on blink-rate of computer-use during the working day, makes this environment harmful, causing more symptoms.

Besides the reported symptoms, a large percentage of workers also had clinical signs of dry eye, and other ocular abnormalities. The clinical findings showed that tear film stability was compromised, as over 60% of participants in Study 2 had a marginal result in the TBUT test (5-10 secs). This was comparable with

the outcome of the PRT test, which also showed a marginal result (10-19 mm) for over 60% of the participants. Of the remaining participants, over 30% had a TBUT of less than 5 secs (Category: Dry), and over 15% had a PRT of less than 10mm (Category: Dry). These values are important to consider alongside the published finding that tear film instability is produced in low relative humidity indoor air,^{35,147} leading to increased ocular pain sensation.¹⁷¹

Study 3 showed that the top 5 reasons for onward referral, in the general, healthy population, were: \geq Grade 2 MGD (over 45%), uncorrected refractive error (nearly 30%), allergy-related (20%), blepharitis (19%), glaucoma suspect (18%), and contact lens-related dry eye 11%. The large proportion with MGD is important, since it can affect lipid layer production, leading to an unstable tear film, which will, in turn, cause a vulnerability to air drafts, low room humidity, and higher air temperature. Moreover, allergies and blepharitis can also be affected by the indoor environment,⁴⁰ and could be a marker for the OHP to investigate indoor air quality.

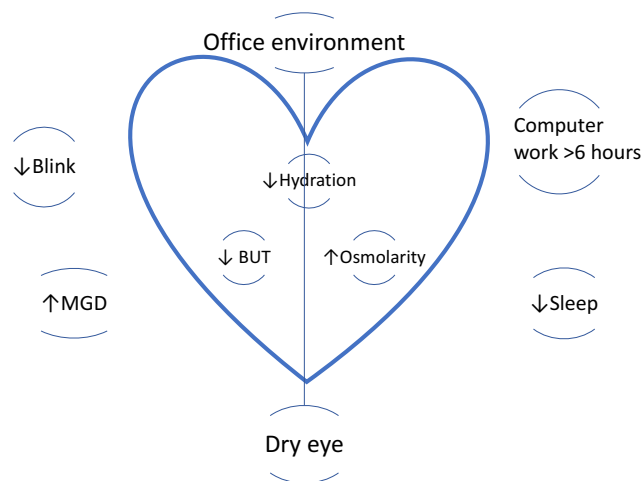


Figure 8-1 The problem at the heart of the office.

All of these findings can be summarised in a simple diagram (Figure 8.1). The typical office worker, involved in highly-demanding visual tasks that require using the computer for more than 6 hours a day, in an adverse environment, can be expected to blink less and have a higher MGD grade, which impacts tear break-up time and tear osmolarity, producing dry eye symptoms. The worker's sleep patterns can also be affected by the computer-use, and the low

humidity can lead to dehydration, both of which are also known to affect dry eye symptoms.

8.1.1 Conclusion: Office workers are vulnerable for DED

The studies have shown that office workers are a group of individuals vulnerable to environmental influences that can produce dry eye symptoms during daily activities at work, and who experience negative influences on their daily activities at work, as well on their social life away from work.

8.2 Primary Healthcare for work-related DED

Changes in the delivery of healthcare, introduced by the government will, in the future, make the optometrist a healthcare professional in “*pre-care*”, as described in the Kaljouw Report (2015),²⁰⁴ with a key role in eye pathology screening. The movement of responsibility for patient care, for select ocular conditions, from ophthalmology to optometry, is currently a discussion topic in the Netherlands. This has been stimulated by the anticipated increase in the number of older adults in the population in the near future. This aging population will increase the need for diabetic, macular degeneration and glaucoma care, which will produce pressure on ophthalmology provision. It is expected that the incidence of DED with the aging population will also increase, creating pressure on the healthcare system.^{72,184,118} The transfer of more responsibility for patient treatment to the optometrist, as “*pre-care*” and “*low-complex care*”, will be needed to meet the expected numbers of eye examinations and disease management in the aging population of the Netherlands.^{119,118} Dry eye disease is a strong candidate for moving treatment responsibility into primary care. Moreover, the complexity of factors involved in the development of office-related dry eye shows the need for a more integrated care model.

Study 4 revealed the difference between GPs and optometrists in their approach to dry eye management. The GPs rely mainly on patient subjective complaints, while the optometrists employ both subjective and objective examination methods. The management options employed by the GPs are also more limited than those of the optometrists. The disparity in approaches

between GPs and optometrists strengthens the belief that clear guidelines on dry eye management are needed. Study 4 also showed that, in establishing management guidelines for dry eye in the Netherlands, there is a need for collaboration not just between GPs and optometrists, but also with other primary care, healthcare professionals. Work-related DED was seen as one reason to develop DED by GPs and optometrists.¹⁴⁵

Study 5 showed the willingness of GPs, optometrists and OHPs to work together, but it also revealed their professional insecurity, particularly about the role of the optometrists. This partly arose from a lack of knowledge about the scope of practice of optometrists, and partly from a concern around the business aspects of optometric practice affecting patient care choices. All of the professionals argued that there is a need for the optometrist to be paid through the insurance system for their consultation and management, to minimise any commercial interest.

There was a consensus that the optometrist and the extra-skilled GP for eye care are the persons to lead in primary care for (dry) eye-related problems, with the further recognition that the optometrist could be the main dry eye specialist (certificated), in the care triad of GPs, OHPs and optometrists. For prevention of eye-related symptoms at work, the OHP has a valuable place in the triad of primary care, eye care professionals.

A good communication system, that allows sharing of patient information, and for referral, was recognised as a critical part of any future healthcare system.

All professionals agreed that there is a need for more knowledge on DED management, and on the effect of the indoor environment and work situation. Education for healthcare providers should be focused on patient-centered care, promoting cooperation among care providers. This can be conducted via continued education.

For office-related dry eye problems, the optometrist can play an important role in providing specialist care, and in explaining the possible management options

to patients. However, for the optometrist to take this role, they will need to be well-educated in disease prevention, health promotion and daily-functioning, and should focus on patient participation by educating the patient on the relationship between health and symptoms. For example, the influence of humidity, light conditions and temperature in aggravating DED should be discussed with the patient. The optometrist also needs to understand their role in an inter-professional cooperation, as the management could include referral to the health and safety consultant at the workplace with a proposed plan of action.

The scope of practice of the optometrist will need to be expanded to enable them to act as primary healthcare practitioners in a more integrated-care model. Inter-professional cooperation with an optometrist would also lead to less referrals to ophthalmologists. To enable that, the optometrist needs to be educated towards inter-professional cooperation.

The negative impact on DED from the office environment, and the use of electronic devices for reading, should not be under-estimated by the optometrist. Referral to or inter-professional communication with an OHP needs to be a management option, alongside the current DED guidelines for treatment. OHPs and GPs also need to be aware of the impact of DED which cannot be covered by current, conventional treatment options.¹⁴⁵

Optometrists and OHPs need to develop a new inter-professional guideline for computer-use by office workers, using the definition for computer-vision syndrome (CVS): “CVS includes ocular symptoms, such as dry eyes, tired eyes, and blurred vision, and extraocular symptoms, such as pain around the eyes and in the neck and shoulders”. The panels agreed that asthenopia should be assessed as part of this examination, especially when pain sensation is one of the symptoms. The specifics about asthenopia were not asked in the study, but it is known that asthenopia symptoms are similar to those for DED.^{46,56}

Many other healthcare professionals need to be consulted as well.^{131,46,56,49,150}
The guidelines need to link inter-professional knowledge between GPs, physiotherapists, ICT consultants, building-experts and architects.

8.3 Recommendations

- 1) A robust RCT is needed to answer to see if a new care system will benefit the DED patient, especially in work-related DED, in preventing dry eye symptoms associated with computer use and the work environment.
- 2) A cost effectiveness study is needed, not only to investigate the cost of care (professional and treatment), but also the indirect costs on work productivity and the social impact of work related DED, and the benefits from work-related prevention.
- 3) The care system needs to be clinically realistic to be cost effective, meaning that the examination needs to be sufficient and efficient, preferably with a specialist DED optometrist in the triad between the GP and OHP.
- 4) Evidence-based guidelines need to be developed, not only for prevention, but also for managing a reintegration process for DED patients. These guidelines need to be imbedded in a care pathway or care system. Looking at previous investigations, DED management, especially for office workers, needs to be within primary care. This care pathway needs to be flexible to meet the needs of the patient and should not consist of a standardised, 'one size fits all', care pathway.

The findings of this thesis could be of influence when developing guidelines for office workers, with and without dry eye symptoms, to promote basic ocular health screening to support the well-being of office workers working in a high visual demand surrounding. Further study on computer-use and decreased blinking, and an development of MGD, along with other factors, such as dehydration during the working day, and sleep disorders due to computer work,

need to be explored. Knowledge of the office environment will be crucial in supporting office workers with symptoms.

- 5) Develop specialism training in DED for optometrists, that is recognised by both optometrists and other healthcare professionals, as the mark of expertise, and which enables these specialist optometrists to be incorporated into the communication and financial compensation systems of the existing primary care structure.
- 6) Knowledge is needed in regard to the ability of DED patients to self-care and self-management, and the guidance from relatives and professionals in primary healthcare, especially in the office work environment.
- 7) Flexible, patient-centred care, with strong inter-profession interactions, is a competence that only can be reached when knowledge of the disease is outstanding, and inter-professional communication is emphasised. This can only be achieved by promoting the development of a dry eye specialism in optometry education.

During the 4-year education program for optometry in the Netherlands, at the University of Applied Sciences (UAS Utrecht), 30 European credit points are reserved for minor education. Currently, the student can choose from 139 minor modules/courses across a wide range of topics. The minor course is considered as an associated course, and this give the opportunity to develop an advanced anterior segment disease minor, with a specialism in DED. This course needs to focus not only on management of the disease, but also on prevention, public-health, and communication towards other healthcare professions. Inter-professional education is needed to educate a flexible, and creative, care professional. This minor needs to be supported with continuing education for the qualified optometrist. By placing the education within the optometry department at the UAS Utrecht, the creation of a certificate in DED specialist could even be part of a Master of Health program, making it available to qualified optometrists and other healthcare professionals, such as the extra-skilled eye care GP.

- 8) Provide education for all healthcare professionals involved in primary care management of DED, by providing local and national CET opportunities, as well as formal training courses for those interested in providing specialist care.

To strengthen primary healthcare, inter-professional cooperation is needed, to promote the delivery of good, local care. Professional insecurity can only be addressed by communication of the scope of practice, knowledge and skills of other healthcare professionals. Moreover, all healthcare professionals would benefit from increased awareness of DED as a public health concern, and of the specifics of DED diagnosis, treatment and management.

There is also a need for clear guidelines of the responsibilities for each professional in management and therapeutic interventions in primary healthcare. There is an opportunity for nationally-guided, local initiatives to initiate communication among locally-working healthcare professionals. Not only should the GP and the OHP be at the table, but also the diabetic nurse and the oncology nurse.

- 9) Research the course of long-term development of dry eye or eye-related discomfort in an aging work population, using standard scales for rating the discomfort of the eye and satisfaction with the workplace and indoor climate.

To the author's knowledge, no investigation has undertaken a cross-sectional investigation, in an office environment, to see the normal aging changes in the tear film, and the possible influences on the tear film from high visual demand work and the indoor environment in a digital environment.

- 10) Examine the relationship between long-term computer-use, sleep disorders, dehydration, and general health on the development of eye-related discomfort symptoms. Air quality should be measured for indoor air temperature, relative humidity and CO₂ levels, and for allergy and hyper-sensitivity, the dust particle concentration should be taken.

Understanding the chronic influences of air quality, relative humidity and temperature on the development of environmental DED would promote: patient awareness of methods to prevent DED; self-management methods to protect the ocular surface; ocular hygiene; and the routine assessment of the refractive status and anterior surface health of the eye.

The participants recruited for these studies should have access to an adjustable light (e.g. desk lamp) at their workstation, to have good physical guiding (head and neck posture), the ability to adjust the screen settings for all the electronic devices used, and the correct visual aids, when needed, all to promote visual comfort when reading.

11) Looking at DED as a public health concern, there is a need for research on the personal and economic consequences of DED, revealed in decreased work productivity, increased illness perception, and increased emotional and social aspects from the influence of DED on the physical aspects of daily life.^{30,115}

The quality of life, eye conditions on function, quality of life, and future needs for medical counseling and rehabilitative services. This follow-up will provide needed information on the long-term evolution of age-related eye conditions. It will also enable us to better understand risk factors for eye conditions that will explain why some people contract these conditions and others are protected.

12) The current optometry education curriculum does not educate the optometrist to be reflective healthcare practitioners. A useful approach to inter-professional education could be to assess perceptions about inter-professional education and practice at the start of a healthcare student's education, and to compare it with that at graduation, and when starting work.

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1. Appendix Overview questions asked by survey A

Outline of survey A
Questions 1- 6: General and health-related questions
1. Consent question
2. What is your age?
3. What is your gender?
4. Are you diagnosed with dry eye disease? 1. No; 2. Yes, my my optometrist; 3. Yes by my GP; 4. Yes by my Ophthalmologist; 5. Yes I am diagnosed with Sjögren's Syndrome
5. In general, how would you rate your overall health? Likert scale 1. Excellent; 2. Very good; 3. Good; 4. Fair; 5. Poor
6. Are you using any eye drops during your working day? 1. Yes; 2. No
Questions 7- 9: Work-related hours, reading tasks
7. Estimation of Working hours per day
8. Estimation of Working hours per week
9. Indicate in percentage to what extent you use each of the following reading situations during a working day: hard copy paper, computer, laptop, tablet, smartphone (total must equal 100%).
Questions 10-12: Symptoms-related questions, by Likert scale
10. Do you experience any of the following symptoms with your eyes, during your working day? Stinging sensation / Burning sensation/ Irritation of the eye/ Itching of the eye/ Tearing of the eye/ Sticky eyelids in the morning/ Pain sensation in the eye/ Pain around the eye/ Photophobia (light sensitivity) /Blurry vision/ Transient vision Choice of answer 1.Yes; 2.No; 3.Sometimes
11. Do you experience any of the following symptoms with your eyes, at home? The same symptoms and answer choice as 10.
12. Are the symptoms that you experience inhibiting you in your daily activities at work? Likert scale: 1. Not at all; 2. Occasionally; 3. Sometimes; 4. Most of the time; 5. Always
Question 13: Working environment, forced choice yes/no
13. Can you answer the following question about your working environment? <ul style="list-style-type: none"> • There is air conditioning Yes /No • There is a window nearby that can be opened Yes /No • There is a day light situation or day light lamps Yes /No • There is adjustable light condition for my work place Yes /No • There is central heating Yes /No • There is an air stream Yes /No
Question 14: Visual aids, forced choice yes/no
14. Are you using any of the following eye correction? <ul style="list-style-type: none"> • Glasses only for distance Yes /No • Glasses multifocal (distance and reading) Yes /No • Glasses specific for computer and reading (computer glasses) Yes /No • Glasses only for reading Yes /No • Contact lenses only for distance Yes /No • Multifocal contact lenses (distance and reading) Yes /No • Mono vision contact lenses (one contact lens for reading) Yes /No

2. Appendix 2 Overview questions asked in survey B

Outline of survey B
General questions:
1) <i>Forced choice for age</i> • 18-30 • 31-40 • 41-50 • 51-60 • 61-65
2) <i>Forced choice for gender: Male/Female</i>
3) <i>Have you consulted with any of the following health care professionals for symptoms of dry eye?</i> 1. GP; 2. Optometrist; 3. Ophthalmologist; 4. Occupational Healthcare Physician; 5. Other (please specify)
4) <i>Are you managing your dry eyes with any of the following possible therapies?</i> 1. Artificial tears; 2. Ointment; 3. Warm compresses; 4. Lid scrubs; 5. Nutrition; 6. Other (please specify)
The validated OSDI questionnaire containing 12 questions
The Work productivity and activity index questions
<p><i>During the past seven days, how many hours did you miss from work because of your dry eyes?</i></p> <p><i>During the past seven days, how many hours did you miss from work because of any other reason, such as vacation, holidays, time off to participate in this study?</i></p> <p><i>During the past seven days, how many hours did you actually work?</i></p> <p><i>During the past seven days, how much did dry eyes affect your productivity while you were working?</i> (Score 0 means Dry eyes had no effect on work, Score 10 means Dry eyes completely prevented me from working)</p> <p><i>During the past seven days, how much did dry eye affect your ability to do your regular daily activities, other than work at a job?</i> (Score 0 means dry eyes had no effect on your daily activities, Score 10 means that dry eyes completely prevented you from doing your daily activities)</p>
Illness perception questionnaire
<p><i>How much does your dry eyes affect your life?</i> Score 0 means no effect at all, Score 10 means severely affect my life</p> <p><i>How long do you think your dry eyes will continue?</i> Score 0 means a very short time, Score 10 means forever</p> <p><i>How much control do you feel you have over your dry eyes?</i> Score 0 means absolutely no control. Score 10 means extreme amount of control.</p> <p><i>How much do you think your treatment can help your dry eyes?</i> Score 0 means not at all, Score 10 means extremely helpful.</p> <p><i>How much do you experience symptoms from your dry eyes?</i> Score 0 means no symptoms at all, Score 10 means many severe symptoms</p> <p><i>How concerned are you about your dry eyes?</i> Score 0 means not at all concerned, Score 10 means extremely concerned</p> <p><i>How well do you feel you understand your illness?</i> Score 0 means don't understand at all, Score 10 means understand very clearly</p> <p><i>How much does your dry eyes affect you emotionally?</i> Score 0 not at all affected emotionally. Score 10 extremely affected emotionally.</p> <p><i>Please list in rank--order the three most important factors that you believe caused your dry eyes.</i></p>

3. Appendix 3 Accepted and published articles

Accepted

Van Tilborg MMA, Kort HSM, Murphy PJ. Dry Eye Disease and Ageing. Gerontechnology

Published

van Tilborg MM, Murphy PJ, Evans KS. Impact of dry eye symptoms and daily activities in a modern office. *Optom Vis Sci* 2017; **6**: 688-3.
