



Comparison of the performance of the dry eye questionnaire (DEQ-5) to the ocular surface disease index in a non-clinical population

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ABSTRACT

Objective: To compare the performance of the dry eye questionnaire (DEQ-5) with the Ocular Surface Disease Index (OSDI) and further validate the DEQ-5 questionnaire.

Methods: A population-based cross-sectional study conducted in Ghana. OSDI and DEQ-5 questionnaires were administered to participants. Cronbach's alpha was used to evaluate the reliability of the OSDI and DEQ-5 questionnaires. Analysis of variance was used to evaluate the discriminant validity of DEQ-5. Concurrent validity was evaluated using the Spearman correlation analysis. A receiver operating characteristic (ROC) curve was generated to describe the sensitivity and specificity of the DEQ-5 questionnaire for diagnosis of dry eye symptoms. Cohen Kappa was used to evaluate agreement between the two questionnaires.

Results: The reliability of the overall OSDI and DEQ-5 scores were 0.919 and 0.819 respectively. The mean (SD) DEQ-5 scores for asymptomatic, mild, moderate and severe dry eye symptoms as defined by the OSDI grading were 3.05 (2.73), 5.13 (3.69), 7.65 (3.30) and 9.77 (4.16) respectively. There was a statistically significant correlation between total OSDI and total DEQ-5 scores ($r_s = 0.649$, $p < 0.0001$). The area under the curve (AUC) of the ROC curve for DEQ-5 was 0.835 (95 % CI: 0.796 – 0.875). A DEQ-5 threshold of 5.5 yielded maximum sensitivity (0.712) and specificity (0.827). The Cohen kappa using a the DEQ-5 total score threshold of 5.5 was $K = 0.539$ ($p < 0.0001$).

Conclusion: In conclusion, performance of the DEQ-5 questionnaire in discriminating symptoms of dry eye is comparable to the OSDI questionnaire. The DEQ-5 questionnaire is a valid measure of dry eye symptoms and can be used as a dry eye symptoms assessment tool in both clinical and epidemiological studies.

1. Introduction

Dry eye disease, also known as keratoconjunctivitis sicca, is a common multifactorial disease of the ocular surface [1] affecting millions of people globally. Considered a major public health issue in different parts of the world, dry eye disease is extensively studied in most developed countries, with relatively high prevalence [2,3]. Dry eye disease is one of the most common reasons for visits to ophthalmic clinicians. Dry eye disease can interfere with the day-to-day activities of individuals, reducing the overall quality of life of patients [4–7] and can be an economic burden on individuals and nations through the cost of management and loss of productivity [8–10]. Dry eye disease can present

with a wide range of symptoms including dryness, grittiness, burning sensation, ocular pain, foreign body sensation and photosensitivity [11].

Diagnosis of dry eye disease is made based on dry eye symptoms and clinical signs. Irrespective of the dry eye clinical sign test used, there is generally a poor correlation between dry eye symptoms and clinical signs [12,13]. This is most likely due to the lack of or few positive clinical signs in dry eye patients with mild or moderate symptoms [14]. There is also poor repeatability of results from clinical tests of dry eye due to the poor correlation between results from the same test performed on the same person at different times [15]. The most repeatable diagnostic tools for dry eye disease are questionnaires for symptoms assessment [15,16]. Dry eye symptoms are generally more predictive of

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dry eye disease diagnosis and play huge roles in diagnosis and management of dry eye disease [17,18]. Dry eye symptoms are routinely assessed using standardized questionnaires. The most frequently used standardized questionnaire for dry eye symptoms is the Ocular Surface Disease Index (OSDI) [19]. The OSDI is a 12-item questionnaire that uses three subscales to assess dry eye symptoms: ocular symptoms, visual related function and environmental triggers [16,19]. Other popular questionnaires are the McMonnies Questionnaire, Standardized Patient Evaluation of Eye Dryness (SPEED), Symptoms Assessment in Dry Eye (SANDE) and Dry Eye Questionnaire (DEQ-5) [20].

The DEQ-5 is a simplified version of the original DEQ. The DEQ-5 consists of five questions that assess the following: frequency of watery eye, discomfort and dryness (scored on a 0–4 scale) and late day discomfort and dryness intensity (scored on a 0–5 scale). DEQ-5 can discriminate dry eye and non-dry eye patients, Sjogren's syndrome dry eye and non-Sjogren's syndrome dry eye and groups with varying dry eye severity [21]. Although the validity and reliability of the DEQ-5 have been reported, the performance of the DEQ-5 questionnaire compared to the OSDI, the most used dry eye symptom questionnaire has not been well-studied. Also, the applicability of the DEQ-5 questionnaire in non-clinical populations is largely unknown as reports on the validity and reliability of DEQ-5 are from clinic-based studies. The purpose of the current study was to compare the performance of the DEQ-5 questionnaire with the OSDI questionnaire and further validate the DEQ-5 questionnaire.

2. Methods

This cross-sectional population-based study was conducted in Ghana between June 2020 and August 2020. The study was approved by the Board of the Department of Optometry and Visual Science at the Kwame Nkrumah University of Science and Technology and adhered to the tenets of the Declaration of Helsinki. Verbal consent for participation was obtained from all participants after the details of the study had been thoroughly explained to them.

Sample size was calculated using the formula:

$$n = [N * X / (X + N - 1)] \quad X = Z_{\alpha/2}^2 * p * (1 - p) / d^2$$

n represents the sample size, N is the population size, $Z_{\alpha/2}$ is the critical value at $\alpha/2$, d is the margin of error and p is the sample proportion. The prevalence of dry eye disease as reported by Asiedu et al. (44.3 %) [22] was chosen as the sample of proportion. The calculated sample size was ≥ 380 .

The capital cities of the Greater Accra and Ashanti regions of Ghana were conveniently selected for data collection due to the ease of access and the availability of research personnel. Study participants were contacted door to door, and questionnaires administered in-person. As many individuals as possible were contacted until the sample size was achieved. One municipal district in each capital city was randomly selected by balloting. In each municipal district, using the town hall as a starting point, every fifth house was selected for sampling. For households with one or two members, all occupants were selected for participation. For households with more than two members, each member of the household was assigned a number after obtaining their consent to participate in the study. A maximum of two individuals were selected from these household for participation through balloting. Individuals 18 years and above were included in the study. Excluded from the study were individuals with an obvious ocular infection or inflammation (from observation of participants eyes), and individuals who had undergone any type of ocular surgery (from self-reported medical history).

2.1. Questionnaires

Two validated questionnaires for dry eye symptom assessment were

used: OSDI and DEQ-5. The OSDI is designed to rapidly assess dry eye-related symptoms within the immediate past week [19]. It is a 12-item questionnaire (Appendix 1). Responses to all questions on the OSDI were scored on a scale of 0–4 (0 = none of the times, 1 = sometimes, 2 = half of the time, 3 = most of the time and 4 = all the time). The overall OSDI score was calculated using the formula: $OSDI = (\text{sum of OSDI scores} \times 25) / (\text{total number of questions})$. The same formula was used to calculate subsection (ocular symptoms, visual related function, and environmental triggers) scores. Overall OSDI score was grouped as normal (<13), mild (13–22), moderate (23–32) and severe (>32) [23]. An individual with OSDI score ≥ 13 was considered positively symptomatic for diagnosis of dry eye disease [23].

The DEQ-5 consists of five questions that assess the following: frequency of watery eye, discomfort and dryness and late day discomfort and dryness intensity (Appendix 2). Responses to frequency of watery eye, discomfort and dryness are scored on a 0–4 scale while responses to late day discomfort and dryness are scored on a 0–5 scales. The overall DEQ-5 was calculated by summing the score on the individual questions. The maximum score that can be obtained on the DEQ-5 questionnaire is 22 [21].

2.2. Statistical analysis

Statistical analysis of data was done with the Statistical Package for the Social Sciences (SPSS) software version 25.0. Mean, standard deviation and percentages were used to describe data, where appropriate. Cronbach's alpha, a measure of internal consistency was used to evaluate the reliability of the OSDI and DEQ-5 questionnaires and their subsections. A Cronbach's alpha value of 0.7 or greater was considered good internal consistency. Analysis of variance (ANOVA) with a Tukey post-hoc was used to evaluate the discriminant validity of DEQ-5 by examining significant differences in DEQ-5 score across different dry eye symptom severity (as defined by the OSDI score). Concurrent validity was evaluated by analysis of correlation between the two questionnaires with the Spearman correlation analysis. Scatterplot was used for the visualization of the correlation between OSDI and DEQ-5. A receiver operating characteristic (ROC) curve was generated to describe the sensitivity and specificity of the DEQ-5 questionnaire. The ROC curve was used to generate a cut-off score for DEQ-5 that maximizes the sum of sensitivity and specificity. This represents a possible cut-off score on the DEQ-5 that is adequate for discriminating between symptomatic and asymptomatic patients. The DEQ-5 cut-off score obtained from the ROC analysis was used to calculate the Cohen Kappa and percentage agreement to evaluate the agreement between OSDI and DEQ-5 in designating participants as symptomatic or asymptomatic. For all analysis, p -value < 0.05 was considered statistically significant.

3. Results

Out of the 435 individuals surveyed, 392 participated in the study giving a response rate of 90.11 %. Majority (58.93 %) of the participants were males. The age range of participants was 18–67 years; mean (SD) age was 26.91 ± 9.42 years. According to the OSDI score grading, 173 (36.48 %) participants were asymptomatic, 62 (15.81 %) had mild dry eye symptoms, 46 (11.73 %) had moderate dry eye symptoms and 111 (28.32 %) had severe dry eye symptoms. The overall mean (SD) OSDI score was 23.86 (22.7); asymptomatic, mild, moderate and severe symptoms were 4.98 (4.21), 17.31 (2.29), 29.41 (10.24) and 54.65 (14.28) respectively. The mean (SD) DEQ-5 score was 5.82 (4.45); mean (SD) score for asymptomatic and symptomatic were 2.47 (1.94) and 9.6 (3.31) respectively.

The internal consistencies of the overall OSDI score, ocular symptoms, vision-related and environmental triggers sub-scores, the overall DEQ-5 score, and the frequency and severity sections are summarized in Table 1. Using the Cronbach's alpha, the reliability of the overall OSDI and DEQ-5 scores were 0.919 and 0.819 respectively. In both

Table 1
Internal consistencies of questionnaires.

		Cronbach's alpha
OSDI	Overall score	0.919
	Ocular symptoms	0.825
	Vision related function	0.858
	Environmental triggers	0.797
DEQ-5	Overall score	0.819
	Frequency section	0.737
	Severity section	0.715

questionnaires, none of the items was negatively correlated with the total, indicative of good internal consistencies and items within questionnaire not being redundant. The inter-item correlation matrix for DEQ-5 were in the range 0.37 – 0.74 and for OSDI was 0.36 – 0.68.

The mean (SD) DEQ-5 scores for asymptomatic, mild, moderate and severe dry eye symptoms as defined by the OSDI grading were 3.05 (2.73), 5.13 (3.69), 7.65 (3.30) and 9.77 (4.16) respectively. Post-hoc analysis using Tukey test for multiple comparisons revealed there was a statistically significant difference ($p \leq 0.003$) in mean DEQ-5 score across the different dry eye symptom severity. Fig. 1 displays the graphical representation of the correlation between total DEQ-5 and OSDI scores. A statistically significant correlation between total OSDI and total DEQ-5 scores was revealed by Spearman correlation analysis ($r_s = 0.649, p < 0.0001$). Categorizing participants into asymptomatic and symptomatic based on the OSDI grading scales, there was a statistically significant correlation between OSDI and DEQ-5 for participants classified as asymptomatic ($r_s = 0.231, p = 0.002$) and symptomatic ($r_s = 0.472, p < 0.001$)

The receiver operating characteristics (ROC) curve, a plot of sensitivity (true positive) vs 1 – specificity (false positive rate), was generated for DEQ-5 total score as shown in Fig. 2. The area under the curve (AUC) of the ROC curve for DEQ-5 was 0.835 (95 % CI: 0.796 – 0.875). Table 2 summarizes the sensitivity and specificity of the DEQ-5 questionnaire. A DEQ-5 threshold of 5.5 yielded maximum sensitivity (0.712) and specificity (0.827). The Cohen kappa using a the DEQ-5 total score threshold of 5.5 was $K = 0.539$ ($p < 0.0001$). The percentage agreement between OSDI and DEQ-5 was 76.78.

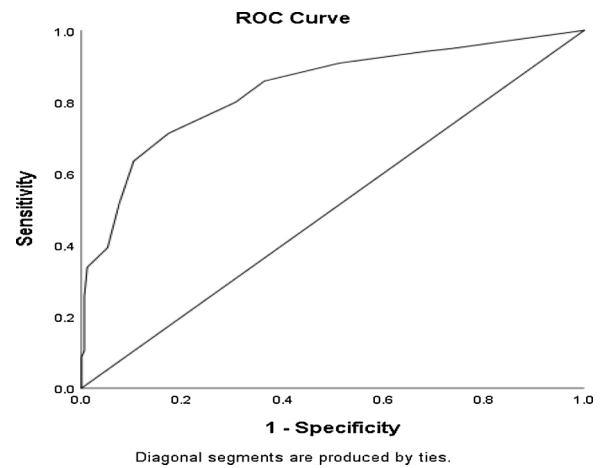


Fig. 2. ROC curve showing the area under the curve of DEQ-5 questionnaire.

Table 2
Sensitivity, specificity and AUC of the DEQ-5.

	Threshold	Sensitivity	Specificity	AUC
Asymptomatic vs symptomatic based on OSDI				
DEQ-5 total score	5.5	0.712	0.827	0.825
Frequency section	3.5	0.699	0.815	0.820
Severity section	1.5	0.785	0.698	0.794

4. Discussion

Dry eye disease presents with a variety of symptoms that affect patient’s quality of life, making symptoms assessment a crucial part of the dry eye disease diagnoses and management process. Although there are several validated dry eye symptoms assessment questionnaires, questionnaires that are short and easily comprehensible but still allow monitoring of symptoms frequency, severity and intensity over the course of the day are valuable. The OSDI questionnaire, the most used dry eye symptoms assessment questionnaire, only measures dry eye

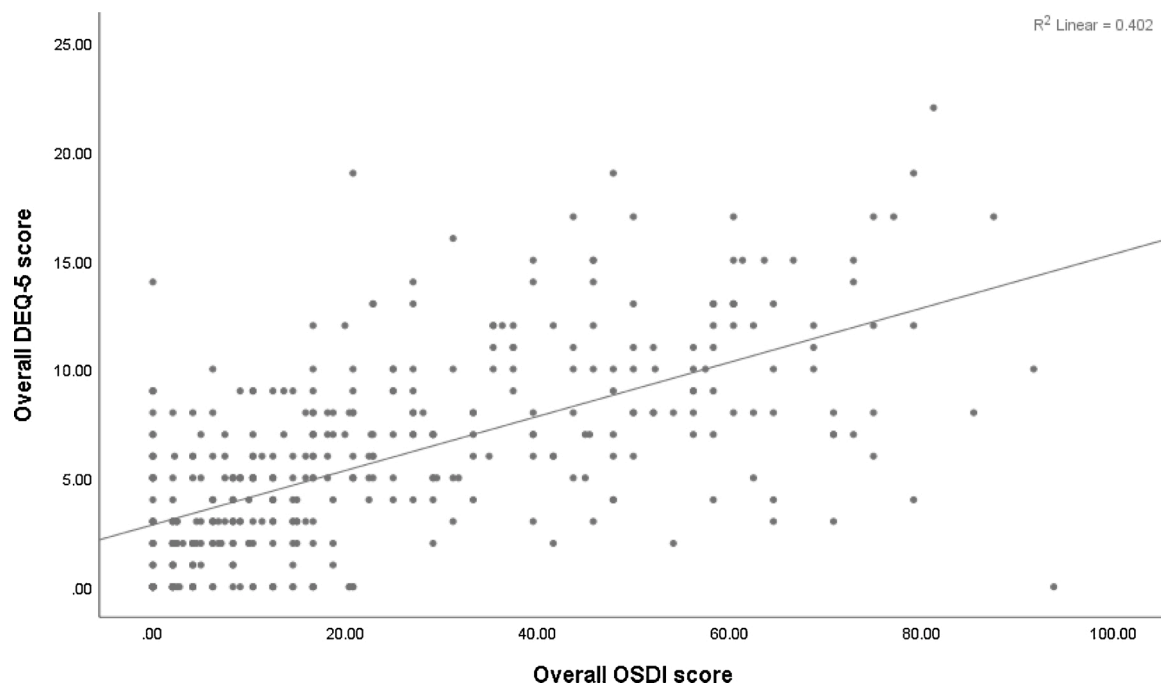


Fig. 1. Scatterplot of the correlation between overall OSDI and DEQ-5 questionnaires score.

symptoms frequency. The DEQ-5 questionnaire, however, is a short 5-item questionnaire that measures dry eye symptoms frequency and is sensitive to dry eye symptoms intensity.

According to the OSDI questionnaire, 63.52 % of participants had overall dry eye symptoms and 28.32 % had severe dry eye symptoms. This agrees with similar studies conducted in Ghana. Kobia-Acquah et al. [24] reported a 69.3 % overall prevalence of symptomatic dry eye and 32.9 % prevalence of severe dry eye symptoms in Ghana. Ghana is in the tropical climate zone, with dry, hot, and windy conditions. The climatic conditions of Ghana might have influenced the high prevalence of overall and severe dry eye symptoms since dry eye symptoms is known to be affected by climatic and environmental conditions such as humidity and wind [25]. Also, the study locations were urbanized cities with relatively high levels of modernization and industrialization in Ghana [26]. As such modernization and industrialization related dry eye factors may be highly prevalent in these cities, contributing to the high prevalence of overall dry eye symptoms and severe dry eye symptoms reported in the current study.

The results from the current study suggest that both the OSDI and DEQ-5 questionnaires have good internal consistencies, though the OSDI questionnaire had a higher internal consistency than the DEQ-5 questionnaire. The internal consistency of OSDI in the current study as estimated by the Cronbach's alpha was similar to that reported by Asiedu et al. [27] and Schiffman et al. [19]. Although all subsections of both questionnaires had good internal consistencies, each of the three subsections of the OSDI had relatively better internal consistency than the two subsections of the DEQ-5 questionnaire. The implication of a questionnaire having a poor internal consistency is that it reduces the power associated with statistical significance tests, making differences in the variable measured by the questionnaire harder to find. Care should however be exercised when interpreting the results of the Cronbach's alpha. Cronbach's alpha value is influenced by the number of items on an instrument; the higher the number of items on an instrument, the greater the probability of obtaining a high Cronbach's alpha coefficient. As such two instruments with different number of items can have the same Cronbach's alpha value but the instrument with the fewer number of items will have a better internal consistency [28]. Item-correlations for the OSDI questionnaire ranged from 0.36 to 0.68 and from 0.37 to 0.74 for the DEQ-5 questionnaire. This shows a relatively better correlation between items on the DEQ-5 questionnaire compared to the OSDI questionnaire.

The DEQ-5 questionnaire had good concurrent validity, evidenced by the relatively strong correlation between the overall score of the DEQ-5 questionnaire and overall score of the OSDI questionnaire. However, there wasn't a perfect correlation between the two questionnaires, indicative of the fact that either questionnaire might capture unique aspects of dry eye disease that the other might not. An imperfect correlation between the two questionnaires was expected owing to the difference in the structure and content of the two questionnaires. The OSDI questionnaire only measures frequency of dry eye symptoms and

their effects on vision-related functioning. The DEQ-5 questionnaire in addition to assessing frequency of dry eye symptoms, is also sensitive to dry eye symptoms intensity.

The AUC obtained from ROC curve analysis can be used as a measure of a test's accuracy or diagnostic precision. It can be interpreted as the probability that a randomly selected "diseased" individual is more likely be classified as diseased by a diagnostic test than a randomly selected "non-diseased" individual [29]. The AUC for the DEQ-5 questionnaire total score was 0.825. This falls into the criteria for a good and useful diagnostic test [30,31]. Contrary to findings from the current study, Wang et al. [32] reported DEQ-5 to not have a good discriminative ability. A notable difference between the current study and that of Wang et al. is the study population. The current study sampled Africans while Wang et al. sampled Europeans, South and East Asians. This might suggest an ethnic or racial difference in the discriminability of the DEQ-5. A DEQ-5 threshold of 5.5 yielded the maximum sensitivity (0.712) and specificity (0.827). The current diagnostic cut-off recommendation for DEQ-5 is a score >6 [21]. The 5.5 threshold in the current study is similar to the diagnostic cut-off value recommendation for DEQ-5. Sensitivity values signify the percentage of participants above the selected threshold that have dry eye symptoms and the specificity values signify the percentage of participants below the given threshold that do not have dry eye symptoms as defined by the OSDI questionnaire [33]. The Cohen kappa value for comparison of the DEQ-5 and OSDI questionnaires was 0.539, indicative of a moderate agreement between the two questionnaires; Cohen kappa values of 0.4 – 0.6 represent moderate agreement [34]. The percentage agreement between OSDI and DEQ-5 was 76.78.

Limitations of the current study are that participants were sampled from an African population only and required participants to not have undergone any ocular surgery. These limitations may affect the applicability of findings from this study to individuals from other races or ethnicity and individuals with dry eye due to ocular surgery. Also, exclusion criteria were assessed by observation and self-reported medical history. These methods of assessment might not be the most accurate.

In conclusion, performance of the DEQ-5 questionnaire in discriminating asymptomatic and symptomatic dry eye is comparable to the OSDI questionnaire. The DEQ-5 questionnaire therefore is a valid measure of dry eye symptoms and can be used as a dry eye symptoms assessment tool in both clinical and epidemiological studies.

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Declaration of Competing Interest

The authors report no declarations of interest.

Appendix 1

Ocular Surface Disease Index© (OSDI©)2

Ask your patients the following 12 questions, and circle the number in the box that best represents each answer. Then, fill in boxes A, B, C, D, and E according to the instructions beside each.

Have you experienced any of the following during the last week?	All of the time	Most of the time	Half of the time	Some of the time	None of the time
1. Eyes that are sensitive to light? . . .	4	3	2	1	0
2. Eyes that feel gritty?	4	3	2	1	0
3. Painful or sore eyes?	4	3	2	1	0
4. Blurred vision?	4	3	2	1	0
5. Poor vision?	4	3	2	1	0

Subtotal score for answers 1 to 5 (A)

Have problems with your eyes limited you in performing any of the following during the last week?	All of the time	Most of the time	Half of the time	Some of the time	None of the time	N/A
6. Reading?	4	3	2	1	0	N/A
7. Driving at night?	4	3	2	1	0	N/A
8. Working with a computer or bank machine (ATM)?	4	3	2	1	0	N/A
9. Watching TV?	4	3	2	1	0	N/A

Subtotal score for answers 6 to 9 (B)

Have your eyes felt uncomfortable in any of the following situations during the last week?	All of the time	Most of the time	Half of the time	Some of the time	None of the time	N/A
10. Windy conditions?	4	3	2	1	0	N/A
11. Places or areas with low humidity (very dry)?	4	3	2	1	0	N/A
12. Areas that are air conditioned?	4	3	2	1	0	N/A

Subtotal score for answers 10 to 12 (C)

Add subtotals A, B, and C to obtain D (D = sum of scores for all questions answered) (D)

Total number of questions answered (do not include questions answered N/A) (E)

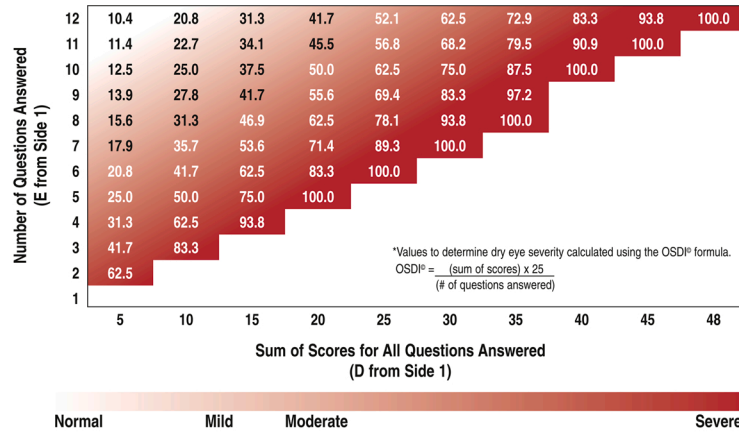
Please turn over the questionnaire to calculate the patient's final OSDI® score.

Evaluating the OSDI© Score1

The OSDI© is assessed on a scale of 0–100, with higher scores representing greater disability. The index demonstrates sensitivity and specificity in distinguishing between normal subjects and patients with dry eye disease. The OSDI© is a valid and reliable instrument for measuring dry eye disease (normal, mild to moderate, and severe) and effect on vision-related function.

Assessing Your Patient's Dry Eye Disease1, 2

Use your answers D and E from side 1 to compare the sum of scores for all questions answered (D) and the number of questions answered (E) with the chart below.* Find where your patient's score would fall. Match the corresponding shade of red to the key below to determine whether your patient's score indicates normal, mild, moderate, or severe dry eye disease.



.....
 Patient's Name: _____ Date: _____

How long has the patient experienced dry eye disease? _____

Eye Care Professional's Comments: _____

1. Data on file, Allergan, Inc.
2. Schiffman RM, Christianson MD, Jacobsen G, Hirsch JD, Reis BL. Reliability and validity of the Ocular Surface Disease Index. *Arch Ophthalmol.* 2000;118:615-621

Appendix 2

DEQ 5

1. Questions about **EYE DISCOMFORT**:

a. During a typical day in the past month, **how often** did your eyes feel discomfort?

- 0 Never
- 1 Rarely
- 2 Sometimes
- 3 Frequently
- 4 Constantly

b. When your eyes felt discomfort, **how intense was this feeling of discomfort** at the end of the day, within two hours of going to bed?

Never <u>have it</u>	Not at All <u>Intense</u>				Very <u>Intense</u>
0	1	2	3	4	5

2. Questions about **EYE DRYNESS**:

a. During a typical day in the past month, **how often** did your eyes feel dry?

- 0 Never
- 1 Rarely
- 2 Sometimes
- 3 Frequently
- 4 Constantly

b. When your eyes felt dry, **how intense was this feeling of dryness** at the end of the day, within two hours of going to bed?

Never <u>have it</u>	Not at All <u>Intense</u>				Very <u>Intense</u>
0	1	2	3	4	5

3. Question about **WATERY EYES**:

During a typical day in the past month, **how often** did your eyes look or feel excessively watery?

- 0 Never
- 1 Rarely
- 2 Sometimes
- 3 Frequently
- 4 Constantly

$$\text{Score: } \begin{array}{cccccc} 1a + 1b + 2a + 2b + 3 & = & \text{Total} \\ \underline{\quad} + \underline{\quad} + \underline{\quad} + \underline{\quad} + \underline{\quad} & = & \underline{\quad} \end{array}$$

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