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Diabetic Retinopathy Screening Uptake Predictors – Understanding Diabetic Patients in Saudi Arabia

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ABSTRACT

Despite the increasing prevalence of Diabetes Mellitus (DM) worldwide, the management of associated comorbidities, such as Diabetic Retinopathy (DR), has been widely unsuccessful. DR causes blindness for approximately 5% of diabetes patients, however, the effectiveness of preventative measures, such as diabetic retinopathy screening (DRS), is significantly impacted by patient attendance. Investigating the factors associated with DRS non-attendance is critical to support health practitioners when designing relevant interventions. This paper, in the context of Saudi Arabia, explores the factors that influence diabetes patients' decision to attend or not attend DRS; to support the integration of patients' personal and clinical data. Such as sociodemographic and socioeconomic factors include patients' age, patients' marital status, patients' education level, patients' income level, patients' residential location, patients' smoking habits, and the existence of related complications (such as hypertension and nephropathy). Data in this cross-sectional study was collected from two diabetic centers in Riyadh; can contains data from 440 diabetes patients. 21.6% of the DM patients had never attended a DRS, 23.6% of the patients had attended a DRS appointment more than 12 months ago, and 54.8% of patients had attended a DRS in the last 12 months. Quantitative data was analyses using Multinomial logistic regression that highlights numerous associations exist between DRS attendance and patient characteristics; These findings emphasize that healthcare providers must consider socioeconomic disparities, mobility, and access issues when designing preventative diabetes care plans and interventions. Additional elaborative research is required to understand and counteract the barriers that exist in the provision of long-term support to DM patients with associated diabetes complications and unhealthy behaviors.

Abbreviations: DM: Diabetes Mellitus; DR: Diabetic Retinopathy; DRS: Diabetic Retinopathy Screening; UK: University of Reading; BMI: Body Mass Index; IMD: Index of Multiple Deprivation

Introduction

Diabetes mellitus (DM) is a physical disorder where the body produces insufficient insulin; resulting in unhealthy blood sugar levels. DM affects more than 463 million adults worldwide, and is predicted to rise to 700 million by 2045 (IDF [1]). Although DM can be managed with regular testing and medication, unmanaged DM is associated with severe and costly health complications, e.g. lower limb amputations, blindness, and chronic renal failure (Rhodes, et al. [2,3]). Blindness occurs as a result of Diabetic Retinopathy (DR), caused by the rupturing of blood vessels and formation of scarring (termed 'proliferative retinopathy') at the back of the eye (Duh, et al. [4]). By 2030, it is estimated that DR prevalence will rise to 191 million worldwide, with 56.3 million facing long-term sight-loss caused by proliferative retinopathy (Thomas [5]). The prevalence of DR in Saudi Arabia had raised from 19.40 % to 44.70% between 2010 and 2019 (Alharbi [6]), and there has been a substantially rise in DR cases as a consequence.

The rise of DM and DR is a significant threat to the health and well-being of Saudi-Arabia's general population, and is a time-bomb to the Saudi economy. In the early stages, DR is often asymptomatic. DR can be managed if diagnosed, but early DR diagnosis is achieved

via preventative diabetic retinopathy screening (DRS). Many countries have used DRS to help manage the long-term impact and cost of DM. The UK government, for example, set a DRS annual attendance target of 80% (Yau, et al. [7]), which led to a marked reduction of DR blindness amongst working-age adults. Although such examples of success show that preventative diabetic retinopathy screening (DRS) can reduce the long-term impact and cost of DR, the benefits of screening are only realised if DM patients can be encouraged to regularly attend DRS sessions.

Non-Attendance in Healthcare

DR scanning and treatment have improved considerably, especially in northern Europe, yet patient attendance still varies considerably (Van Eijk [8]). In Saudi Arabia, the number of diabetic patients, and the number of linked health complications, continues to rise (Yousef, et al. [9]), yet the use of the DRS has been largely unsuccessful. Understanding of the factors impacting non-attendance in Saudi Arabi is essential to health practitioners in the designing of relevant interventions; i.e. increasing attendance rates and improving preventive care (Baumeister, et al. [10-13]). Although screening can reduce the impact of DR, there appears to be considerable variation in patient attendance in Saudi Arabia. Literature implies various reasons why DM patients may not attend Diabetic Retinopathy Screening (DRS) sessions; such as: lack of awareness, limited access to healthcare, financial constraints, fear and anxiety, or complacency. Interestingly, research investigating the cause of non-attendance has failed to consider the impact of many sociodemographic, socioeconomic, and individual characteristics, behaviours, or comorbidities.

Accordingly, this research identifies, as a result of individual differences, how attendance factors vary across the population. The factors influencing a patient's decision to attend a DRS session seem to vary significantly over time, and patients that previously attended a DRS session, but have now decided not to attend, may be influenced by factors irrelevant to new patients, e.g. experience of the last appointment. Most studies, however, do not capture and compare data from different attendance groups. To counter this, our analysis will consider patients who

1) Attended a DRS session in the last 12 months (optimal attendance),

2) Attended a DRS session more than 12 months ago (low attendance), or

3) Have never attended DRS (no attendance). Factors associated with previous attendance should therefore be investigated separately. The research questions considered in this research are:

A. RQ1. What Sociodemographic factors impact DRS attendance within Saudi diabetic centres?

B. RQ2. What Socioeconomic Factors impact DRS attendance within Saudi diabetic centres?

C. RQ3. What individual

a) Health behaviour and diabetic characteristics, and

b) Comorbidities significantly impact the likelihood of a patient not attending a DR screening?

Methodology

Study Design and Participants

As the research questions concerns identification of significant variation amongst DR patients, a quantitative methodology was deemed appropriate. Collection and analysis of quantitative electronic medical data was used to identify factors impacting the defined outcomes. Using an existing medical data increases the accuracy of results; avoiding the potential response bias of self-reporting data. Moreover, the use of a quantitative methodology allows a large sample size and reduction of experimenter bias; ensuring consistency in data collection and analysis. The purpose and design of the current study was systematically checked and carried out in line with the University of Reading (UK) ethical rules. Secondary data was obtained (with full permission) from diabetic centers at King Fahad Medical City and King Salman Hospital, Riyadh, Saudi Arabia. The clear sampling criteria was DM patients (either type 1 or type 2 diabetes) aged ≥18 years. Although both hospitals used electronic medical records, the required information could only be captured by reviewing patient data individually within the software application (as database access was not possible). Participant identification, and data collection, required completion of two stages.

- The first stage related the identification of eligible patient data from hospital medical records. Relevant contact information, demographic (age, gender, ethnicity, marital status), socioeconomic status (education level, income level, employment, residential location), and medical information (cigarette smoking, body mass index (BMI), DM type, duration, and treatment, hypertension, dyslipidaemia, glycaemic control, nephropathy, and neuropathy) was collected for eight-hundred and twenty-four potential participants (n=824). For each potential participant, attendance status (i.e., optimal-attendance / low-attendance / non-attendance) was the calculated. Syntactic and semantic uniformity was used to ensure consistent capture of indicator information (Appendix Table 1). Any missing data was identified and flagged.

- The second step required the researcher phoning each potential participant to

i. Request ethical permission to use their data within the study, and

ii. To populate (where required) any missing data points. Con-

tactable participants were told the purpose of the study. Participation consent had to be obtained from all participants, and the participant was given the option to withdraw from the study at any time. Several patients declined to participate and were excluded from the study. Many other potential participants were non-contactable, and these were also excluded from the study.

Table 1 lists characteristics of the final sample (n=440) using descriptive statistics. Within this sample, 21.6% of DM patients had never attended a DRS session (non-attendance), 23.6% of DM patients had attended a DRS session yet not within the last 12 months (low attendance), and 54% of DM patients had attended a DRS session in the last 12 months (optimal-attendance).

Appendix Table 1: Study indicator syntax and semantics.

Variables		Variable measurements scale	Variables	Category
Sociodemographic	Age	≥ 30 =1	Ethnicity	Saudi = 1
		31-40 year =2		Yamani = 2
		41-50 year =3		Sudanese = 3
		51-60 year =4		Pilipino = 4
		≤ 60 year =5		
	Gender	Male = 1	Marital status	Single= 1 Married=2 Divorced=3
		Female = 2		Widowed =5
	Ethnicity	Saudi = 1	Income level (Saudi riyal)	<3000 = 1
		Yamani = 2		<7000 =2
		Sudanese = 3		<10,000 =3
		Pilipino = 4		<15,000 =4
				15,000+ =5
Socioeconomic	Education level	Illiterate =1	Employment	Government employee =1
		Primary = 2		Nongovernment employee =2
		Intermediate =3		Self-employed =3
		Secondary =4		Student =4
		University =5		Housekeeping =5
		Vocational =6		Retired =6
	Residential location deprivation	Central = 1		
		Eastern = 2		
		Northern =3		
		Southern =4		
		Western =5		

Health behaviour and diabetic characteristics	Body Mass Index	(≤15 Km / m) - Severely underweight = 1 (of 16 - ≤18.5) Underweight = 2	Cigarette smoking	No = 0
		(BMI of 18.5 - ≤ 25 Normal (healthy weight) = 3		Yes = 1
		(BMI of 25- <30) Overweight = 4		Ex-smoking = 2
		(BMI of 30- <35) Obese Class I (Moderately obese) = 5		
		(BMI of 35- < 40) Obese Class II (Severely obese) = 6		
		(BMI of ≥ 40) Obese Class III (Very severely obese) = 7		
	Diabetes duration (years)	≤ 5 = 1	Type of diabetes	Type 1 = 1
		6- 9 = 2		Type 2 = 2
		10 – 19 = 3		
		≥ 20 years = 4		
	Treatment of DM	Diet alone = 1 Oral medicine = 2 Insulin = 3		
		Insulin bump = 4 Liraglutide injection = 5		
Comorbidities	Hyperglycaemia - HbA1c	Controlled: ≤ 6.5 = 1	Dyslipidaemia	No = 1
		Not controlled: ≥ 6.5 = 2		Yes = 2
	Hypertension	No = 1	Nephropathy	No = 1
		Yes = 2		Yes = 2

Table 1: Study Population Characteristics (n=440).

	Variable	Group	n	Percentage
	Attendance	Never attended - non-attendance	95	21.6
		Last eye examination > 12 months - low	104	23.6
		Last eye examination < 12 months - optimal	241	54.8
Sociodemographic characteristics	Gender	Male	171	38.9
		Female	269	61.1
	Ethnicity	Saudi	423	96.1
		Non-Saudi	17	3.9
	Age	≥ 30	101	23.0
		31-40 years	55	12.5
		41-50 years	67	15.2
		51-60 years	119	27.0
		≤ 60 years	98	22.3
	Marital status	Single	89	20.2
		Married	296	67.3
		Divorced	20	4.5
		Widowed	35	8.0

Socioeconomic characteristics	Income level (Saudi riyal)	<3000	92	20.9
		3000- <7000	89	20.2
		7000 - <10,000	138	31.4
		100000 - <15,000	61	13.9
		15000 or more	60	13.6
	Employment	Government employee	74	16.8
		Non-government employee	36	8.2
		Self-employed	23	5.2
		Student	45	10.2
		Homemaker	177	40.2
		Retired	85	19.3
	Residential location	Central	358	81.4
		Eastern	18	4.1
		Northern	24	5.5
		Southern	22	5.0
		Western	18	4.1
	Education level	Illiterate	73	16.6
		Primary	68	15.5
		Intermediate	55	12.5
		Secondary	90	20.5
		University	130	29.5
Health behaviour	Cigarette smoking	Yes = 1	167	38.0
		No = 2	253	57.5
		Ex-smoker = 3	20	4.5
	Body mass index	Severely underweight	1	0.2
		Underweight	12	2.7
		Healthy weight	74	16.8
		Overweight	128	29.1
		Moderately obese	123	28.0
	DM Duration	≤5	88	20.0
		6- 9	102	23.2
		10 - 19	182	41.4
		≥20	68	15.5
Diabetes comorbidities	Hypertension	No	216	49.1
		Yes	224	50.9
	Dyslipidaemia	No	179	40.7
		Yes	261	59.3
	Glycaemic control	Normal	79	18.0
		Abnormal	361	82.0
	Nephropathy	No	328	74.5
		Yes	112	25.5
	Neuropathy	No	361	82.0
		Yes	79	18.0

Data Analysis Approach

Multiple models were used to consider different key factors. The study used the AIC estimator to find the best approximating model without overfitting it. AIC is calculated to consider

i) The number of independent variables used to build the model, and

ii) The maximum likelihood estimates of the model (i.e., how well the model reproduces the data).

The lowest final score model, when comparing the AIC full model value (i.e., containing all the predictors) to the null model (or intercept only model; i.e., no predictors) indicates the best fit for the data. The -2 Log Likelihood index for the final model needed to be less than its counterpart value for the null model, i.e., in order to indicate that the final model is a good fit. The statistically significant value of the Chi-square indicates that the final model has a good predictive and statistical significance, i.e., the final model predicts more accurately than the null one. Diabetic Retinopathy Screening Uptake Predictors – Understanding Diabetic Patients in Saudi Arabia

Results

Sociodemographic Characteristics

The result (Table 2) from the multinominal regression analysis of (RQ1) presented how DRS attendance predictors related to sociodemographic characteristics (age, gender, ethnicity, marital status). Result indicated that the final model is a good fit for the data, as the value of the Chi-square test was 37.048, which is statistically significant at ($p \leq .005$). The results contain Likelihood Ratio Tests for the same data within Table 3. Each variable (or predictor) is compared to the whole model to determine whether each variable can be added to the full model, i.e. to determines the main contribution of each predictor variable to the overall effect. Since the problem is a multiclass problem with multiple possible outcomes, multinomial logistic regression was used to determine the independent variables significantly impacting DRS attendance, which involved predicting probabilities across the three defined attendance scenarios. Multinomial logistic regression analysis revealed significant association of some independent variables with DRS attendance groups (Table 4).

Table 2: RQ1 Model Fitting Information.

Model	Model-Fitting Criteria		Likelihood Ratio Tests		
	AIC	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept only	211.121	207.121			
Final	210.073	170.073	37.048	18	.005

Table 3: H1 Likelihood Ratio Tests.

Model	Model-Fitting Criteria		Likelihood Ratio Tests		
	AIC	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept	210.073	170.073a	.000	0	.
Gender	209.539	173.539	3.465	2	.177
Ethnicity	207.786	171.786	1.713	2	.425
Age	215.513	191.513	21.439	8	.006
Marital status	208.251	180.251	10.178	6	.117

Table 4: Factors associated with DRS attendance.

	Variables	Last Eye Examination (> 12 months)					Last Eye Examination (< 12 months)				
	Attendance [a]	B	Std. Error	Wald	Sig.	Odds Ratio Exp(B)	B	Std. Error	Wald	Sig.	Odds Ratio Exp(B)
Socio-demographic characteristics	Intercept	-.896	1.088	.679	.410		1.541	.762	4.087	.043	
	[Age ≤ 30 years]	1.860	.708	6.910	.009	6.424	1.229	.639	3.700	.054	3.419
	[Age = 31-40 years]	.688	.532	1.673	.196	1.990	.069	.472	.021	.884	1.072
	[Age = 41-50 years]	-.243	.499	.238	.626	.784	-.343	.406	.712	.399	.710
	[Age = 51-60 years]	-.726	.444	2.676	.102	.484	-.568	.344	2.715	.099	.567
	[Age ≥ 60 years]	0[b]	.	.	.	.	0[b]	.	.	.	.
	[Marital Status = Single]	-.860	.898	.917	.338	.423	-1.511	.745	4.111	.043	.221
	[Marital Status = Married]	.261	.665	.154	.694	1.299	-.467	.508	.846	.358	.627
	[Marital Status = Divorced]	-.058	1.118	.003	.959	.944	.400	.794	.254	.614	1.493
	[Marital Status = Widowed]	0[b]	.	.	.	.	0[b]	.	.	.	.

Only age and marital status were found to have a significant impact on DRS attendance between category groups. When comparing non-attendance and low-attendance groups, patients who were 30 years (or younger) were 6.4 times more likely to have low attendance rather than non-attendance (b=1.860, s.e.=.708, p<.01). When comparing non-attendance with optimal attendance, younger patients (<=30) were also 3.4 times more likely to have optimally attendance rather than non-attendance (b=1.229, s.e.=.639, p=.05, OR=3.419) – see Table 4. Marital status significantly impacts DRS attendance; i.e. when comparing non-attendance with optimal DRS attendance (b=-1.511, s.e.=.745, p=.04). Single patients were only 4% as likely to attend as married patients, and single patients were only 22% as likely to attend DRS as widowed patients (OR=.221). This result implies that single patients are significantly more at risk to developing health issues is left unmanaged.

Socioeconomic Variables

The result from the multinominal regression analysis of (RQ2) presented the results of the DRS attendance predictors related to socioeconomic characteristics (education level, income level, employment, living environment). This result indicated that the final model is a good fit for the data, as the value of the Chi-square test is 107.467, which is statistically significant at (p < .0001), as shown in Table 5. The results contain Likelihood Ratio Tests for the same data within Table 6. Each variable (or predictor) is compared to the whole model to determine whether each variable can be added to the full model, i.e. to determines the main contribution of each predictor variable to the overall effect. Education level (b=-1.638, s.e.=.810, p=.043), residential location (b=-3.67, s.e.=.841, p<.0001), and income level (b=2.027, s.e.=.732, p=.006) were found to be significant predictors, when comparing non-attendance with optimal attendance (Table 7). Adult patients with only a vocational education (i.e., intermediate) were significantly less likely to have optimal DRS session attendance (OR=.194).

Table 5: RQ2 Model Fitting Information.

Model	Model-Fitting Criteria		Likelihood Ratio Tests		
	AIC	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept only	559.455	555.455			
Final	523.987	447.987	107.467	36	.000

Table 6: RQ2 Likelihood Ratio Tests.

Model	Model-Fitting Criteria		Likelihood Ratio Tests		
	AIC	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept	523.987	447.987a	.000	0	.
Education level	514.921	458.921	10.933	10	.363
Income level	583.043	523.043	75.056	8	.000
Employment	514.942	458.942	10.955	10	.361
Living environment	522.311	462.311	14.323	8	.074

Table 7: Factors associated with DRS attendance.

	Variables	Last Eye Examination (> 12 months)					Last Eye Examination (< 12 months)				
	Attendance [a]	B	Std. Error	Wald	Sig.	Odds Ratio Exp(B)	B	Std. Error	Wald	Sig.	Odds Ratio Exp(B)
Socioeconomic characteristics	Intercept	1.043	1.265	.680	.410		3.169	1.143	7.683	.006	
	[Education level = Illiterate]	- 1.357	.926	2.146	.143	.258	-.852	.828	1.058	.304	.427
	[Education level = Primary]	-.879	.895	.964	.326	.415	-.822	.823	.996	.318	.440
	[Education level = Intermediate]	- 1.515	.889	2.905	.088	.220	-1.638	.810	4.086	.043	.194
	[Education level = Secondary]	-.842	.836	1.014	.314	.431	-1.282	.779	2.707	.100	.278
	[Education level = University]	-.702	.811	.749	.387	.496	-.828	.754	1.206	.272	.437
	[Education level Vocational]	0[b]	.	.	.	.	0[b]	.	.	.	.
	[Income level = <3000] SR	- 2.258	.988	5.226	.022	.105	-3.670	.841	19.022	.000	.025
	[Income level = 3000- <7000] SR	-.503	.967	.270	.603	.605	-2.580	.841	9.425	.002	.076
	[Income level = 7000 - <10,000] SR	-.260	.932	.078	.780	.771	-2.998	.819	13.401	.000	.050
	[Income level = 100000 - <15,000] SR	- 1.188	.998	1.415	.234	.305	-2.861	.855	11.196	.001	.057
	[Income level = 15000 or more] SR	0[b]	.	.	.	.	0[b]	.	.	.	.
	[Residential location = Central]	.687	.662	1.075	.300	1.987	2.027	.732	7.673	.006	7.593
	[Residential location = Eastern]	.223	.891	.063	.802	1.250	1.161	.943	1.513	.219	3.192
	[Residential location = Northern]	.753	.891	.715	.398	2.124	1.868	.916	4.162	.041	6.478
	[Residential location = Southern]	.831	.854	.946	.331	2.295	1.036	.919	1.270	.260	2.817
	[Residential location = Western]	0[b]	.	.	.	.	0[b]	.	.	.	.

Patients with a low income, i.e., less than 3000 Saudi Riyal per month, were also found to be significantly more likely to have non-attendance; i.e. when compared to either low attendance (b=- 2.258, s.e.=.988, p=.022) or optimal attendance (b=-3.670, s.e.=.988, p=.022) groups. Interesting all income groups, when compared to the highest income category, i.e., 15000 or more Saudi Riyal per month, were significantly less likely to achieve optimal attendance. This result suggests that the cost of attendance – whether this is time and/or finance - impacts most patients in achieving optimal attendance at DRS sessions. Finally, residents who live in urbanised central regions, are significantly more likely to have optimal attendance (OR=7.59); supporting the suggesting that ease of access, and cost in time / money, required to attend the DRS attendance is a significant driver behind DRS session attendance.

Health Behaviour

The result from the multinominal regression analysis of (RQ3a) present the results of the DRS attendance predictors related to health-related behaviour and diabetes characteristics (i.e. Smoking, Body Mass Index {BMI}, type of Diabetes Mellitus {DM}, diabetes duration, and DM type). The value of the Chi-square test as an indicator of the final model's goodness-of-fit is equivalent to 90.028, which is statistically significant at ($\alpha \leq .001$). This indicates the statistical significance of the final model fit, as shown in Table 8. Smoking was the only health-related factor that significantly impacts patient attendance (Table 9). Patients who smoke are more likely than non-smoking diabetic patients to not attend the DRS regularly (b=-3.131, s.e.=1.163, p=.007) or optimal attendance (b=-2.406, s.e.=1.068, p=.024) behaviour – see Table 10.

Table 8: RQ3a Model-Fitting Information.

Model	Model-Fitting Criteria		Likelihood Ratio Tests		
	AIC	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept only	520.880	516.880			
Final	498.852	426.852	90.028	34	.000

Table 9: RQ3a Likelihood Ratio Tests.

Model	Model-Fitting Criteria		Likelihood Ratio Tests		
	AIC	-2 Log Likelihood	Chi-Square	df	Sig.
Smoking	536.261	472.261	45.409	4	.000
Body Mass Index (BMI)	486.415	438.415	11.563	12	.481
DM duration	492.817	432.817	5.966	6	.427
DM treatment	483.791	431.791	4.939	10	.895
DM type	497.138	429.138	2.286	2	.319

Table 10: Factors associated with DRS attendance.

	Variables	Last Eye Examination (> 12 months)					Last Eye Examination (< 12 months)				
	Attendance [a]	B	Std. Error	Wald	Sig.	Odds Ratio Exp(B)	B	Std. Error	Wald	Sig.	Odds Ratio Exp(B)
Health behaviour and diabetes	Intercept	1.729	1.467	1.388	.239		2.418	1.328	3.314	.069	
	[Cigarette smoking = Yes]	-3.131	1.163	7.248	.007	.044	-2.406	1.068	5.075	.024	.090
	[Cigarette smoking = No]	-1.003	1.150	.760	.383	.367	-1.301	1.074	1.466	.226	.272
	[Cigarette smoking= Ex- smoking]	0b	.	.	.	.	0b	.	.	.	.

Testing Comorbidities

The result from the multinominal regression analysis of (RQ3b) present the results of the DRS attendance predictors related to comorbidities. Comorbidities refers to the presence of two or more chronic conditions or diseases in a person at the same time. Multinominal regression analysis was conducted to test the DRS attendance predictors related to diabetes comorbidities (Hypertention, Dislipidemia DLP, Glycaemic Control, Nephropathy, Neuropathy). This result indicated that the final model is a good fit for the data, as the value of the Chi-square test is 23.788, which is statistically significant at (p =.008), as shown in Table 11. The value of the Chi-square in Table 12 is statistically significant at ($p \leq .05$) in the case of the two variables (Hypertension, Nephropathy). This indicates that both contribute statistically to the prediction of the dependent variable Diabetes Retinopathy Screening attendance (DRS attendance). The values of the other Chi-squares are not statistically significant in the case, which indicates that they are too weak to contribute to predicting the dependent variable (DRS attendance).

Table 11: Comorbidities Model-Fitting Information.

Model	Model-Fitting Criteria		Likelihood Ratio Tests		
	AIC	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept only	180.849	176.849			
Final	177.060	153.060	23.788	10	.008

Table 12: Comorbidities Likelihood Ratio Tests.

Model	Model-Fitting Criteria		Likelihood Ratio Tests		
	AIC	-2 Log Likelihood	Chi-Square	df	Sig.
Interception	177.060	15 3.060a	.000	0	.
Hypertension	179.791	An 159.791	6.731	2	.035
Dyslipidemia	173.097	153.097	.037	2	.982
Hyperglycemia HbA1c	176.826	156.826	3.765	2	.152
Nephropathy	184.656	164.656	11.595	2	.003

Hypertension and nephropathy predicted DRS attendance. Patients who did not have hypertension had a 2.3 times higher likelihood of low attendance (b=.847, s.e.=.350, p=.016) rather than not attendance; though optimal attendance was not significantly impacted by existence of hypertension – see Table 13. patients without neuropathy are less likely to attend both low-attendance screenings (b=-1.181, s.e.=.376, p=.002) or optimal (b=-.903, s.e.=.337, p=.007) attendance group – see Table 13; suggesting that existence of nephropathy has a significant impact on patient ability to manage attendance at a DRS session.

Table 13: Factors associated with DRS attendance.

	Variables	Last Eye Examination (> 12 months)					Last Eye Examination (< 12 months)				
	Attendance [a]	B	Std. Error	Wald	Sig.	Odds Ratio Exp(B)	B	Std. Error	Wald	Sig.	Odds Ratio Exp(B)
Diabetes co-morbidities	Intercept	1.104	.440	6.286	.012		1.641	.401	16.737	.000	
	[Hypertension = No]	.847	.350	5.851	.016	2.333	.232	.293	.630	.427	1.262
	[Hypertension = Yes]	0[b]	.	.	.	.	0[b]	.	.	.	.
	[HbA1c = Normal]	-.743	.391	3.611	.057	.476	-.292	.298	.961	.327	.747
	[HbA1c = Abnormal]	0[b]	.	.	.	.	0[b]	.	.	.	.
	[Nephropathy = No]	-1.181	.376	9.851	.002	.307	-.903	.337	7.188	.007	.405
	[Nephropathy = Yes]	0[b]	.	.	.	.	0[b]	.	.	.	.

Discussion

Although preventative screening has been established in many Saudi hospitals, many patients with diabetes fail to access this service, and therefore fail to benefit from an annual provision that would

i) Help patients manage the onset of DR,

ii) Improve DM patient health and well-being, and

iii) Reduce the significance of the financial and social impact of DM in Saudi Arabia. Investigating the factors associated with DRS attendance is key to increase the uptake of DRS screening; itself essential to managing interventions that improve patient long-term care and wellbeing. Although DR is the most common diabetes complication, and annual screening is advised, this study found that 23.6% of diabetic patients had not attended DRS for more than 12 months, while 21.6% had never done so.

RQ1 - Sociodemographic Factors

When considering sociodemographic variables, age and marital status (but not gender and ethnicity), were found to significantly affect DRS attendance.

Age: The findings presented in this study are in conflict with numerous studies published in the USA, Canada, and South Korea (Rim, et al. [11,14]); and many implying that a lower DRS uptake is expected in younger patients (Cook, et al. [11,15,16]), for example,

showed that elderly Koreans were much more likely to use eye-care services than younger Koreans. Rim et al. suggested that elderly individuals have more free time, and are more able to attend screening appointments. Our results showed that Saudi Arabian patients under 30 years in age are significantly more likely to attend DRS screening than older patients. Interestingly this result aligns with the findings of Salam and Siddiqui's [17], who showed that patients under 40 were more compliant with dietary appointments; since comorbidities can reduce the mobility of elderly patients. The issue of decreasing mobility raises a serious question – Are elderly patients physically able to travel to, and/or access, DRS services. If older DM individuals struggle to travel to, or are not able to practically access the DRS sessions, then increased non-attendance in elderly groups is explained. Since non-attendance has a significant impact on the long-term health and wellbeing of patients, and the cost to the state, this is question of mobility and access needs to be considered by Saudi health authorities.

Marital Status: Rim, et al. [11] showed that diabetic patients without a spouse were less likely to visit an eye clinic than diabetic patients with a spouse. Salam and Siddiqui's [17] found that married Saudi diabetic patients were more compliant with medication. Lee [18] showed that bereaved Korean diabetic patients had a significantly lower attendance than married patients. Our study also confirmed this result, and also identified that single individuals are significantly less likely to achieve optimal DRS attendance than either married or widowed patients. The impact of a spouse is undeniable in a diabetic patient's life. The existence of a partner increases the likelihood of a patient attending a DRS session, which is key to their long-term health and well-being. Additional research is certainly needed to

i) Determine whether the existence of a spouse influences: social pressure, care support (including increasing mobility), positive mental health and/or well-being, and

ii) What barriers exist for single DM patients and these barriers might be overcome. The non-significance of gender also corroborates the findings of Sachdeva, et al. [19] who also claimed that gender did not impact DRS attendance.

RQ2 - Socioeconomic Factors

Several UK studies have investigated the impact of deprivation on DRS uptake (e.g. Lindenmeyer, et al. [20,21]). Since Saudi Arabia, unlike the UK, does not possess an explicit Index of Multiple Deprivation (IMD), this research examined the most common socioeconomic characteristics; i.e., education level, employment type, residential location, and income. Our findings showed that all socioeconomic factors, except employment status, were found to be significant in predicting DRS attendance.

Education Level: Knowledge, gained through education, provides patients with an understanding, and health literacy, that supports the control and management of their health-related behaviour and lifestyle (Lee, 2015). Our finding suggest that poorly educated patients were less likely to achieve optimal DRS attendance than highly educated ones, which is consistent with the assertion of previous researchers (Rim, et al. [10,11,22]). Interestingly, Al-Shehri, et al. [23] showed that less-educated Saudi diabetic patients expressed significantly fewer concerns about their health than those in higher education, suggesting that awareness does improve DRS attendance, but can also improve patient anxiety. It is tempting to suggest that ignorance is bliss, however Saudi-based research by Alzahrani, et al. [24], found that 59% of patients knew that diabetes can cause blindness, but most were unaware that DR was the mechanism, and that this could be measured and managed. Lower- educated, and partially informed patients, seemingly fail to appreciate the value of preventive care in avoiding longer-term DM complications (Baumeister, et al. [10,11,18]). Ignorance negatively impacts a patients' ability to avoid significant DM complications, and our finding agree with existing research (e.g., Herath [25]) that claims that general education in critical; especially concerning the importance of DRS attendance to long-term management of health and well-being.

Income: Some studies suggest that low income is not an obstruction to DRS attendance, since the cost of screening is covered by the national health services or insurance (Rim, et al. [11). Although (in Saudi Arabia) the medical cost of DRS session is covered, our results show that patients with higher income were significantly more likely than lower-income diabetics to attended a DRS session; demonstrating a clear association between household income and DRS attendance. Our results echo findings that household income positive influences DRS rates (Assefa, et al. [11,18,26]). Furthermore, it is suggested that low income negatively impacts both diabetic patients' access to medical services and their treatment-related perceptions and behaviour. Duan, et al. [27] found that 75% of interviewees with proliferative DR reported economic concerns, and that some had concealed health problems or delayed accessing health treatment for financial reasons. Moreover, economically deprived patients are often forced to choose the nearest healthcare provider during the early stages of treatment (due to travel costs). Further investigation of the impact of cost on patient behaviour is certainly needed; i.e., to determine why DRS attendance is impacted despite the lack of direct treatment cost.

Residential Location: Previous research, examining the effect of rural versus urban residence on DRS attendance, has shown that restricted access to services, and the additional effort required to attend DRS sessions, makes non-urban citizens more likely to miss DRS appointments (Rim [11,18,28]). Consistent with this result, we found that patients in the largely urban Central district of Saudi Arabia were significantly more likely to attend an appointment every 12 months (i.e., optimal attendance); confirming that the location of DR screening centres impacts screening uptake (Hipwell, et al. [18,29]). Making attendance easy, and removal of attendance barriers is key to patient attendance. Home visits, and the use of mobile screening units, which are designed to bring retinal imaging and screening services to more convenient locations, are certainly a solution that should be considered by policy makers and/or medical care practitioners in more rural areas.

RQ3a - Health Behaviour and Diabetic Characteristics

Previous research show that the time elapsed since DM diagnosis significantly impacts DRS attendance; with authors discussing the growing importance of annual examination to patients' health and wellbeing (Lee 2015; Low, et al. [16,21,28]). Similarly, health-related characteristics (such as BMI and DM type) can influence the patients need to keep DRS appointments (Scanlon, et al. [16,28]). Our study found that only smoking status (but not BMI, DM duration, or DM type) will significantly influence DRS attendance.

Smoking Behaviour: Our results show that smokers were much more likely than non-smokers (or ex- smokers) to be in the low- or non-attendance groups. This result confirms the findings, in context of Saudi Arabia, presented previously in Baumeister [11,18], which states that non-smokers have the highest rates of DRS. Although additional qualitative research is required to fully understand this result, we infer that non-smokers are more health aware, and more likely to pay attention to public health campaigns and educational materials about the impact and dangers of poor behaviour, which could contribute to their increased onus concerning the importance of DRS attendance.

RQ3b - Comorbidities

Diabetes mellitus is associated with comorbidities including hypertension, dyslipidaemia, retinopathy, neuropathy, and nephropathy; and many diabetic patients receive hospital care for multiple DR related comorbidities. Much research identifies comorbidities as a compounding risk factor for DR patient health (Karoli, et al. [21,30]).

Hypertension: Rim, et al. [11,28] stated that DM patients with comorbidities, utilised medical services more often. Our results showed, however, that DM patients without blood pressure issues were more significantly likely (i.e., than patients with hypertension) to undertaken low- attendance instead of non-attendance. High blood pressure is caused by a combination of genetic, environmental, and lifestyle factors, but there is a strong correlation in literature between the existence of blood pressure and self-efficacy (Zareban, [31]); i.e., an individual's belief in their own ability to successfully perform a specific task or achieve a particular goal. Our result is consistent with the findings of other studies (Sachdeva, et al. [11,19,32]) that suggests that patients who are more driven towards achieving a goal, are more likely to manage their health and/or overcome the barriers limiting DRS attendance. Additional research is certainly needed to investigate the direct impact of self-efficacy on DRS attendance.

Nephropathy: Patients without nephropathy (kidney disease) were found to be significantly less likely than those with kidney disease to be in low or optimal attendance group – see Table 13. This result suggests DM patients suffering from kidney disease are less likely to attend DRS sessions. It is not clear from our results why this is so. The treatment of nephropathy typically involves a combination of lifestyle changes (e.g. initially regular exercise and dietary modification), medication (including medications to manage blood pressure, control blood sugar levels, and underlying conditions like diabetes or autoimmune disorders), and, in some more advanced cases, medical interventions (such as dialysis). Additional research is required to understand our result for different levels of nephropathy, as the barriers limiting DRS session attendance most likely changes over time. Our result highlights that the existence of comorbidities significantly impacts patients' DRS attendance, however there appears some variance, as a result of the comorbidity type, and additional research is certainly required to investigate the causes for barriers for different patient groups.

Conclusion

Although the prevalence of diabetes is rising in the Kingdom of Saudi Arabia, limited research has been done to fully understand the local DM complications in order to design effective preventative care management. This exploratory study considers how sociodemographic (RQ1), socioeconomic (RQ2), and health-related behavioural factors (including comorbidities) (RQ3) impact screening attendance behaviour. The results address the three defined research questions, and supports the identification of high-risk groups, i.e., patients less likely to attend DRS sessions. This study identified that age and marital status (sociodemographic factors), Education level, Income, and residential location (socioeconomic), and Smoking, Hypertension and Nephropathy (health-related behavioural factors) all significantly impact patient DRS attendance. Many of the barriers to patient DRS session attendance appear linked to access and mobility issues, yet the use of a quantitative methodology prevents us from undertaking critically discussion as to why these factors impact attendance and/or how barriers need to be addressed in order to facilitate equity to health services. The authors recommend further qualitative elaboration why factor significance exists. Future research is also required to support healthcare providers in the effective design, implementation, and maintenance of behavioural intervention mechanisms.

Author Contributions

Samraa Hussain: Data curation, Methodology, Software, Writing-Original draft preparation. Stephen Gulliver: Supervision, Writing-Reviewing and Editing, Mona Ashok: Visualization, validation, Markos Kyritsis; reviewing the statistical result.

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Statement on Conflicts of Interest

The authors declare that they have no conflict of interest.

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Ethics

The data collection of this study and research instruments were approved by the ethical committee of the Saudi Ministry of Health and King Fahad Medical City in Riyadh. IRB Registration Number with KACST, KSA:H-01-R-012, IRB Registration Number with OHRP/NIH, USAIRB00010471 (162).

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