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Prevalence of age-related macular degeneration and its association with systemic risk factors

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ABSTRACT

Objectives: The objective of the study is to assess the prevalence of age-related macular degeneration (ARMD) and identify measurable risk factors strongly associated with ARMD, aiding clinicians in implementing preventive interventions.

Materials and Methods: A total of 500 patients aged 50 years and older were enrolled. Data collection was done using a structured case record form. This cross-sectional observational study was conducted in the Ophthalmology outpatient department of a tertiary care hospital in Gujarat. Descriptive statistics were used to analyse demographic and clinical variables, and logistic regression analysis was employed to assess the associations between risk factors and ARMD. A $p < 0.05$ was considered statistically significant.

Results: Out of 500 participants, 56 cases of ARMD were identified, indicating a prevalence of 11.2%. The prevalence was slightly higher in males (12.1%) compared to females (10.2%). Statistically Significant associations were observed between ARMD and risk factors such as diabetes, hypertension, ischaemic heart disease, high body mass index and smoking. Age, alcohol use and tobacco chewing do not show a statistically significant association.

Conclusion: The study highlights an 11.2% prevalence of ARMD in the elderly. The study emphasises the urgent need for targeted screening, risk factor modification and early intervention strategies tailored to the regional demographic. Enhanced public health initiatives and clinician awareness are essential to reduce the burden of ARMD-related visual impairment and improve the quality of life for the elderly population in western Gujarat.

Keywords: Age-related macular degeneration, Association, Prevalence, Risk factors, Screening

INTRODUCTION

Age-related macular degeneration (ARMD) is a progressive, degenerative disease that affects the macula, the central part of the retina responsible for central vision. It is a leading cause of irreversible vision loss and blindness in older adults globally.[1] ARMD is generally classified into two forms: Dry (non-exudative) and wet (exudative). Drusen deposits and gradual retinal thinning characterise the more common dry form. In contrast, the wet form is less prevalent but more severe, characterised by the abnormal growth of blood vessels under the retina, which can lead to rapid and severe vision loss.[2]

As the global population continues to age, ARMD is emerging as a major public health challenge. It is estimated that by the year 2040, nearly 288 million people worldwide will be affected.[1] Although ARMD was previously seen primarily in high-income countries, the disease is now gaining attention in low- and middle-income nations, including India, due to demographic shifts, urbanisation and increased life expectancy.

In India, several population-based studies have explored the prevalence of ARMD. The Andhra Pradesh Eye Disease Study and the India Eye Disease Study (INDEYE) highlighted a significant burden of ARMD in individuals aged 50 years and above.[3,4] Prevalence rates vary widely across regions: From 1.1% in south India to 4.7% in north India.[5,6] The Central India Eye and Medical Study reported early ARMD at 2.7% and late ARMD at 0.3% in a rural cohort.[7] Globally, ARMD contributes to 8.7% of total blindness and is the third leading cause of blindness worldwide.[8]

The disease is influenced by both non-modifiable risk factors (age, genetics and family history) and modifiable factors such as smoking, hypertension (HTN), obesity, poor diet and prolonged sun exposure.[9] Despite this understanding, many

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individuals remain undiagnosed until late stages due to a lack of awareness and insufficient screening programs – especially in rural and underserved areas of India.[10]

ARMD significantly impacts quality of life, limiting daily activities such as reading, driving and recognising faces. It also leads to increased dependency, risk of falls and psychological distress. As India's elderly population is projected to reach nearly 20% by 2050, the burden of ARMD and other age-related eye diseases is expected to grow substantially.[11] In addition, the visual disability caused by ARMD contributes to increased healthcare costs and socioeconomic burden due to lost productivity and the need for long-term care.

Despite its far-reaching impact, ARMD remains underdiagnosed in India due to poor access to eye care and the absence of structured screening initiatives.[10] Early detection and intervention can slow disease progression and reduce the risk of severe vision loss. Assessment of the prevalence of ARMD and risk factors strongly associated with ARMD, which can be easily assessed by clinicians, helps in implementing preventive interventions.

Primary objective

1. To estimate the prevalence of ARMD among individuals aged ≥50 years in the population of Gujarat.

Secondary objective

1. To identify the major risk factors associated with ARMD, including demographic, lifestyle and systemic health conditions
2. To explore associations between modifiable risk factors and the presence of ARMD
3. To provide evidence-based recommendations for screening and preventive strategies to reduce the burden of ARMD in the Indian population.

MATERIALS AND METHODS

Study setting

The present study is a hospital-based study done in patients visiting the ophthalmology outpatient department (OPD) at a tertiary care centre over a duration of 2.5 years.

Study design

Hospital-based cross-sectional observational study.

The required sample size was calculated using Kelsey's formula through StatCalc in Epi Info Software with taking care of other systemic risk factors.[12] A total of 500 participants will be included in the study. This sample size ensures sufficient statistical power to detect meaningful associations between ARMD and its risk factors.

Inclusion criteria

1. Age >50 years
2. Willing to provide informed written consent
3. Able to undergo a complete ophthalmologic evaluation.

Exclusion criteria

1. Age <50 years
2. Denial of consent
3. History of laser photocoagulation treatment
4. Presence of high myopia (more than −6.00 D)
5. History of other macular diseases (e.g., macular dystrophy, macular hole)
6. History of ocular trauma
7. Any condition that precludes a proper fundus examination
8. Patients with psychiatric illness.

Ethics

The study protocol received approval from the Institutional Ethics Committee (IEC) before commencement. The IEC thoroughly reviewed our research proposal, ensuring that it complied with ethical guidelines and safeguarded the rights and well-being of participants. We obtained informed consent from all participants involved in the study. This process entailed providing comprehensive information about the study's objectives, procedures, potential risks and benefits. Participants were informed that their involvement was voluntary and that they had the right to withdraw from the study at any point without any repercussions. We ensured that participants fully understood the information provided and had the opportunity to ask questions before signing the consent form. To protect the confidentiality of participants, we implemented stringent data protection measures. Personal identifiers were removed from data records to maintain anonymity.

Methodology

Participant recruitment and consent

Participants were recruited from the Ophthalmology OPD of a tertiary care hospital in western Gujarat. Inclusion and exclusion criteria were applied during screening. All participants received information about the study's objectives, procedures and confidentiality in their preferred language. Written informed consent was obtained before any examination or data collection.

Demographic and clinical data collection

Demographic details, including age, sex, occupation and residential status, were recorded. A structured interview

using a case record form was conducted to obtain personal and medical history, including HTN, diabetes mellitus, ischaemic heart disease (IHD), cerebrovascular accidents, smoking, alcohol or tobacco use and family history of ARMD or ocular diseases.

General examination

Blood pressure (BP) was measured using a calibrated sphygmomanometer after a 5-min rest. Systolic BP >120 mmHg and diastolic BP >80 mmHg were considered elevated. Anthropometric measurements included height, weight and body mass index (BMI), categorised as underweight (≤18.5 kg/m^2), normal (18.5–24.9), overweight (25–29.9) or obese (≥30).

Laboratory investigations

Fasting blood sugar (FBS), post-prandial blood sugar (PPBS) and serum cholesterol levels were measured in the hospital laboratory using standard techniques. FBS >126 mg/dL, PPBS >200 mg/dL and cholesterol >200 mg/dL were considered elevated.

Ocular examination

A complete eye examination included visual acuity testing (unaided and best-corrected), slit-lamp biomicroscopy, intraocular pressure measurement with Goldmann tonometry and dilated fundus examination. Fundus findings such as drusen, retinal pigment epithelium changes, atrophy, haemorrhages, pigment epithelial detachment and choroidal neovascular membrane were noted.

Imaging

Optical coherence tomography was performed to evaluate retinal changes in suspected ARMD. Fundus photography was used for documentation and classification. Patients were categorised based on the Age related eye disease study classification into no ARMD, early, intermediate or late ARMD.

Statistical analysis

The data analysis aimed to evaluate the prevalence of ARMD and identify its significant risk factors through statistical correlation.

A descriptive statistics used to summarise baseline characteristics of the study population:

1. Continuous variables such as age and BMI were presented as mean ± standard deviation
2. Categorical variables such as gender and presence of HTN were summarised using frequencies and percentages.

Regression analysis was used. Variables showing statistical significance ($p < 0.05$) in univariate analysis were entered into a multivariate logistic regression model to identify independent predictors of ARMD. Odds ratios with 95% confidence intervals (CIs) were calculated. A $p < 0.05$ was considered statistically significant.

RESULTS

Tables 1 and 2 shows that this cross-sectional observational study was conducted to evaluate the prevalence and associated risk factors of ARMD among individuals aged 50 years and above in western Gujarat. A total of 500 participants were enrolled in the study, with an almost equal gender distribution: 264 males (52.8%) and 236 females (47.2%). The mean age of the study population was 66.93 ± 9.66 years. In Table 3, the age and sex-wise distribution of patients in the study group is described.

The mean best corrected visual acuity was 0.82 logMAR among patients with ARMD (n = 56), compared to 0.43 logMAR in the non-ARMD group (n = 444), indicating significantly poorer visual acuity in patients with ARMD. Patients with wet ARMD (n = 10) had a mean best-corrected visual acuity of 1.97 logMAR, whereas those with dry ARMD (n = 46) had a mean BCVA of 0.60 logMAR, indicating worse visual acuity in the wet ARMD subgroup. The non-ARMD group also demonstrated visual acuity lower than the standard reference, likely due to the presence of cataract, posterior capsular opacification and uncorrected refractive

Table 1: Univariate logistic regression analysis for factors associated with ARMD.

Risk factor	OR	95% CI	*p*-value
Diabetes mellitus	1.36	1.09-1.69	<0.00001
Hypertension	6.17	3.56-10.69	<0.00001
Ischemic heart disease	4.57	2.15-9.70	<0.00001
Systolic BP >120 mmHg	6.46	3.07-13.58	<0.00001
Diastolic BP >80 mmHg	5.87	3.12-11.02	<0.00001
FBS >126 mg/dL	7.19	3.89-13.28	<0.00001
PPBS >200 mg/dL	18.75	5.32 - 66.04	<0.00001
Serum cholesterol >200 mg/dL	4.18	2.35-7.42	<0.00001
BMI >25 kg/m^2	3.61	2.02-6.46	<0.00001
Smoking	5.93	3.24-10.86	<0.00001
Tobacco chewing	0.62	0.33-1.16	0.114
Age >60 years	1.18	0.66-2.10	0.281
Male gender	1.22	0.70-2.12	0.489
Alcohol consumption	0.93	0.48-1.79	0.829
Cerebrovascular stroke	0.97	0.20-4.69	0.860

ARMD: Age-related macular degeneration, FBS: Fasting blood sugar, OR: Odds ratios, CI: Confidence interval, BMI: Body mass index, PPBS: Post-prandial blood sugar, BP: Blood pressure, p<0.05: Statistically significant

Table 2: Multivariate logistic regression analysis for independent predictors of ARMD.

Risk factor	Adjusted OR	95% CI	*p*-value
Hypertension	3.96	2.12-7.39	<0.001
FBS >126 mg/dL	3.21	1.78-5.78	<0.001
Smoking	3.48	1.92-6.29	<0.001
Serum cholesterol >200 mg/dL	2.74	1.49-5.03	0.001
Diabetes mellitus	2.41	1.38-4.20	0.002
Ischemic heart disease	2.87	1.34-6.15	0.006
BMI >25 kg/m²	2.12	1.16-3.86	0.014
Tobacco chewing	0.79	0.41-1.51	0.480
Age >60 years	1.21	0.68-2.17	0.510
Male gender	1.14	0.62-2.10	0.670
Alcohol consumption	0.88	0.44-1.76	0.715
Cerebrovascular stroke	1.02	0.21-4.94	0.970

ARMD: Age-related macular degeneration, FBS: Fasting blood sugar, OR: Odds ratios, CI: Confidence interval, BMI: Body mass index, $p<0.05$: Statistically significant

Table 3: Age and sex-wise distribution of patients in the study group.

Age group (in years)	Male (%)	Female (%)	Total (%)
50–60	78 (15.6)	78 (15.6)	156 (31.2)
61–70	84 (16.8)	67 (13.4)	151 (30.2)
71–80	81 (16.2)	69 (13.8)	150 (30)
81–90	20 (4)	22 (4.4)	42 (8.4)
>90	1 (0.2)	0	1 (0.2)

errors, including myopia, hypermetropia, astigmatism, as well as presbyopia. Visual loss in dry ARMD results from progressive RPE and photoreceptor degeneration due to drusen accumulation and geographic atrophy, causing gradual central vision loss. OCT shows drusenoid RPE elevations and outer retinal disruption. In contrast, wet ARMD causes rapid vision loss from choroidal neovascularisation with fluid and haemorrhages on OCT.

OCT macula done in ARMD cases, from which 6 cases were type 1 CNVM (from which 2 had subretinal fluid), 3 cases were type 2 CNVM (from which 1 had intraretinal fluid), 1 case was type 3 CNVM and 0 cases were of PCV noted.

Prevalence of ARMD

A large systematic review and meta-analysis by Wong *et al.* estimated the global prevalence of ARMD to be 8.7%, with early ARMD affecting approximately 8% and late ARMD about 0.4% of the population.[1]

The study revealed a prevalence of ARMD of 11.2% (56 out of 500). Among these 10 were wet ARMD and 46 were dry ARMD cases. No ARMD cases were treated before. Among these, 32 cases were males (12.1% prevalence among males) and 24 were females (10.2% prevalence among females) (in males, univariate logistic regression analysis, $p = 0.489$, multivariate logistic regression analysis, $p = 0.670$).

Age distribution and ARMD

Although ARMD prevalence increased with advancing age, age did not emerge as an independent risk factor after adjustment (univariate logistic regression analysis, $p = 0.281$; multivariate logistic regression analysis, $p = 0.510$).

Systemic comorbidities and ARMD

Diabetes mellitus

Diabetes was significantly associated with ARMD. Among the 141 diabetic patients, 19 had ARMD (of whom 3 had diabetic retinopathy, among them 1 had mild nonproliferative diabetic retinopathy (NPDR) and 2 had moderate NPDR), whereas only 37 out of 359 non-diabetics had ARMD (univariate logistic regression analysis, $p < 0.00001$; multivariate logistic regression analysis, $p = 0.002$). Diabetes was a strong independent predictor of ARMD. Hyperglycaemia likely contributes through oxidative stress, endothelial dysfunction and retinal microvascular damage.

HTN

HTN also demonstrated a strong correlation with ARMD. Of 123 hypertensive participants, 34 had ARMD, while only 22 of the 377 non-hypertensive participants were affected (univariate logistic regression analysis, $p < 0.00001$; multivariate logistic regression analysis, $p = 0.001$). HTN showed the strongest independent association with ARMD, supporting the vascular hypothesis in macular degeneration pathogenesis.

IHD

IHD was present in 37 individuals, of whom 12 developed ARMD. In contrast, among 463 participants without IHD, only 44 had ARMD. IHD remained significantly associated with ARMD (univariate logistic regression analysis, $p < 0.00001$; multivariate logistic regression analysis, $p = 0.006$), suggesting shared atherosclerotic and inflammatory mechanisms.

Cerebrovascular stroke

Only 7 individuals had a history of stroke, with 2 of them showing ARMD. Cerebrovascular stroke is not statistically significant as a risk factor for ARMD (univariate logistic

regression analysis, $p = 0.860$; multivariate logistic regression analysis, $p = 0.970$).

Blood glucose levels and ARMD

FBS and PPBS levels showed a strong and statistically significant relationship with ARMD. Of the 94 participants with FBS >126 mg/dL, 42 had ARMD, compared to 14 out of 406 with FBS ≤126 mg/dL (univariate logistic regression analysis, $p < 0.00001$; multivariate logistic regression analysis, $p = 0.01$). Among those with PPBS >200 mg/dL, 8 had ARMD out of 12 individuals, confirming hyperglycaemia as a key modifiable risk factor (univariate logistic regression analysis, $p < 0.00001$).

Serum cholesterol and ARMD

Hypercholesterolaemia was significantly associated with ARMD. Among participants with cholesterol levels >200 mg/dL, 29 had ARMD compared to 27 out of 445 participants with cholesterol levels ≤200 mg/dL (univariate logistic regression analysis, $p < 0.00001$; multivariate logistic regression analysis, $p = 0.81$). This association was highly significant, suggesting a potential link between lipid metabolism and macular degeneration.

BMI and ARMD

Overweight and obesity were significant risk factors. Participants with BMI >25 accounted for 24 ARMD cases (22 in the 25–29.9 range and 2 in the >30 range), while only 1 ARMD case was recorded in the underweight group (≤18.5). Those with normal BMI (18.5–25) had 31 cases. Overweight and obesity were independently associated with ARMD, likely mediated through systemic inflammation and metabolic stress (univariate logistic regression analysis, $p < 0.00001$; multivariate logistic regression analysis, $p = 0.014$).

Lifestyle factors: Smoking, alcohol and tobacco

Smoking

Smoking was strongly associated with ARMD. Among 126 smokers, 33 had ARMD (21 male and 12 female), in contrast to only 23 out of 374 non-smokers. This validates tobacco smoking as a critical modifiable risk factor (univariate logistic regression analysis, $p < 0.00001$; multivariate logistic regression analysis, $p < 0.001$).

Alcohol consumption

There was no significant association between alcohol use and ARMD, suggesting alcohol does not play a major role in this context (univariate logistic regression analysis, $p = 0.829$; multivariate logistic regression analysis, $p = 0.715$).

Tobacco chewing

Tobacco chewing was reported in 217 participants, of whom 18 had ARMD. This association did not reach statistical significance (univariate logistic regression analysis, $p = 0.114$; multivariate logistic regression analysis, $p = 0.480$).

DISCUSSION

This cross-sectional observational study evaluated the prevalence and associated risk factors of ARMD among 500 individuals aged ≥50 years in Western Gujarat. The prevalence of ARMD was found to be 11.2%, highlighting the significant burden of this degenerative condition in the ageing Indian population.

Age and gender

Although a rising trend of ARMD with advancing age was observed, it was not statistically significant (Univariate Logistic Regression Analysis, $p = 0.281$; Multivariate Logistic Regression Analysis, $p = 0.510$), possibly due to the limited number of participants in the oldest age groups. This contrasts with studies like INDEYE and the Beaver Dam Eye Study, which demonstrated a clear age-associated increase in ARMD prevalence.[4,13] Gender did not significantly influence ARMD occurrence in our study (In males, univariate logistic regression analysis, $p = 0.489$; multivariate logistic regression analysis, $p = 0.670$), aligning with findings from the Chennai glaucoma study and research from Bangladesh, although other studies have reported a slight female predominance.[14,15]

Systemic conditions

A strong, statistically significant association was observed between ARMD and HTN (univariate logistic regression analysis, $p < 0.00001$; multivariate logistic regression analysis, $p = 0.001$), diabetes mellitus (univariate logistic regression analysis, $P < 0.00001$; multivariate logistic regression analysis, $p = 0.002$) and FBS >126 and PP2BS >200 (univariate logistic regression analysis, $p < 0.00001$, multivariate logistic regression analysis, $p = 0.001$).[16] These findings support previous research, such as the ARMD India study and the Singapore Indian Eye Study, underscoring the importance of systemic vascular health in ARMD pathogenesis.[17]

Lipid profile

Elevated serum cholesterol (>200 mg/dL) was significantly associated with ARMD (Univariate logistic regression analysis, $p < 0.00001$; multivariate logistic regression analysis, $p = 0.81$), suggesting that lipid dysregulation contributes to drusen formation and retinal degeneration. These findings are supported by both the Blue Mountains Eye Study and the AREDS reports.[18,19]

BMI

A U-shaped relationship was noted, with increased ARMD prevalence in both underweight (≤18.5 kg/m^2) and overweight (>25 kg/m^2) individuals (Univariate logistic regression analysis, $p < 0.00001$; multivariate logistic regression analysis, $p = 0.014$). This is consistent with global studies suggesting both malnutrition and obesity can contribute to retinal degeneration through oxidative stress and systemic inflammation.

Lifestyle factors

Smoking emerged as a major modifiable risk factor, with a significantly higher ARMD prevalence in smokers (26.2%) compared to non-smokers (5.3%) (univariate logistic regression analysis, $p < 0.00001$; multivariate logistic regression analysis, $p < 0.001$). This supports evidence from the AREDS, Beaver Dam and Blue Mountains Eye Studies.[13,17,18] In contrast, alcohol consumption (univariate logistic regression analysis, $p = 0.829$; multivariate logistic regression analysis, $p = 0.715$) and tobacco chewing (Univariate logistic regression analysis, $p = 0.114$; multivariate logistic regression analysis, $p = 0.480$) were not significantly associated with ARMD in this study.

Limitations

This study's limitations include that it was a hospital-based study; an ideally community-based study would have been best suited for measuring the/prevalence of ARMD in the population. Prevalence may be higher due to this selection and inclusion bias in this study, reliance on self-reported lifestyle data and regional focus in western Gujarat. Advanced imaging like OCTA was not used, and there was no follow-up to assess disease progression. These factors may affect the generalisability and depth of the findings.

CONCLUSION

This cross-sectional observational study assessed the prevalence and risk factors of ARMD in individuals aged 50 and above in western Gujarat, revealing a prevalence of 11.2%. In conclusion, this study identifies several key modifiable risk factors—hypertension, diabetes, dyslipidaemia, abnormal BMI, and smoking—as significantly associated with ARMD, emphasising the need for integrated ocular and systemic health screening in ageing populations.While age showed a rising trend with ARMD, significant associations were found with HTN, diabetes, hyperlipidaemia, abnormal BMI and smoking. These findings align with global research, highlighting ARMD's multifactorial nature. The study emphasises the urgent need for targeted screening, risk factor modification and early intervention strategies tailored to the regional demographic. Enhanced public health initiatives and clinician awareness are essential to reduce the burden of ARMD-related visual impairment and improve the quality of life for the elderly population in western Gujarat.

Ethical approval: The research/study was approved by the Institutional Review Board at GMERS Medical College and Hospital, Gotri, Vadodara, number IHEC/23/OUT/SRPG099, dated 22 November 2023.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given consent for clinical information to be reported in the journal. The patient understands that the patient's names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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