

(VLW) model was used to assess economic losses. Bayesian age-period-cohort modelling and the Shared Socioeconomic Pathways framework were used to project future disease and economic burdens through 2050.

Results Despite a continued decline in the age-standardised DALY rate (ASDR), global AMD DALYs increased from 1990 to 2021, driven primarily by population growth and ageing. The VLW attributable to AMD increased nearly fourfold, reaching US\$643.74 billion in 2021 and accounting for 0.42% of global GDP. In 2021, women bore a greater absolute VLW (US\$46.06 billion), whereas smoking-attributable economic losses (US\$69.35 billion) were concentrated among men. Sociodemographic index (SDI) and VLW/GDP showed a non-linear relationship. Heterogeneity was observed in VLW and VLW/GDP across regions. Although ASDRs are projected to continue declining, both DALYs and welfare losses are expected to increase by 2050.

Conclusions This study suggests that reliance solely on epidemiological indicators may underestimate the societal and economic burden of AMD. The substantial heterogeneity in economic burden across SDI groups highlights the need for tailored, region-specific policies. Smoking-attributable economic losses are particularly pronounced among men. Absolute health and economic burdens are projected to continue increasing.

1. INTRODUCTION

Age-related macular degeneration (AMD) is a leading cause of irreversible blindness and vision loss among older adults worldwide.^{1,2} Beyond impairing visual function, AMD compromises

independence, mental health, and quality of life, placing a substantial burden on patients, families, and healthcare systems.³ As the global population ages, this burden continues to grow, with the number of affected individuals projected to reach 288 million by 2040.⁴ Although anti-vascular endothelial growth factor (anti-VEGF) therapy has markedly improved visual outcomes, AMD remains incurable and typically requires lifelong treatment and follow-up,^{5,6} resulting in sustained costs for individuals and healthcare systems. Moreover, the consequences extend well beyond vision loss to include lost productivity,^{7,8} increased caregiving needs, and complications such as falls and fractures.^{9,10}

Previous studies have extensively characterised the epidemiological burden of AMD, including prevalence, incidence, and disability-adjusted life years (DALYs). Although most studies have focused on the direct medical costs associated with nAMD, diabetic retinopathy (DR), and diabetic macular edema (DME), estimates of non-medical costs are also needed to capture the full economic burden associated with these conditions.¹¹ Existing economic evaluations have focused mainly on direct healthcare costs or treatment expenditures within individual countries—global direct costs attributable to AMD are estimated to exceed US\$255 billion.¹² The broader economic consequences of AMD-related blindness and vision loss remain inadequately characterised. Unlike epidemiological indicators, economic losses are determined not only by the number of affected individuals but also by socioeconomic factors—including income levels, labour force participation, informal caregiving costs, and willingness to pay—that vary substantially across regions. Consequently, whether the economic burden of AMD mirrors the regional distribution of its health burden remains unknown. Among the established risk factors

for AMD,^{13,14} smoking is modifiable and thus a key target for prevention.¹⁵ Although the association between smoking and AMD has been extensively studied, the contribution of smoking to the economic burden of AMD has not been quantified. Moreover, future trends in the health and economic burdens of AMD have not yet been systematically projected.

To identify the drivers of the increasing health burden of AMD and its economic consequences, including disparities across development levels and between sexes, we used data from GBD 2021 to comprehensively assess the burden of AMD-attributable blindness and vision loss at global, regional, and national levels from 1990 to 2021. Using the Value of Lost Welfare (VLW) model,^{16,17} which captures both market and non-market losses,^{18,19} we identified drivers of changes in health burden, quantified the economic burden of AMD, evaluated smoking-attributable economic losses, and projected the health and economic burdens of AMD through 2050.

2. METHODS AND MATERIALS

The GBD 2021 provides a comprehensive and internally consistent framework for comparing health burdens and associated risk factors across locations, sexes, and age groups from 1990 to 2021. Using data from GBD 2021, we systematically assessed global and national epidemiological trends in AMD-attributable blindness and vision loss between 1990 and 2021. Given that AMD predominantly affects middle-aged and older adults, and that the GBD 2021 estimates indicate non-zero DALYs among individuals aged ≥ 45 years, we focused our analysis on the health and economic burden of AMD in populations aged ≥ 45 years. The analysis focused on DALYs, a standard epidemiological metric that captures both premature