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BCLA CLEAR Presbyopia: Epidemiology and impact

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A R T I C L E I N F O

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A B S T R A C T

The global all-ages prevalence of epidemiologically-measured 'functional' presbyopia was estimated at 24.9% in 2015, affecting 1.8 billion people. This prevalence was projected to stabilise at 24.1% in 2030 due to increasing myopia, but to affect more people (2.1 billion) due to population dynamics. Factors affecting the prevalence of presbyopia include age, geographic location, urban versus rural location, sex, and, to a lesser extent, socioeconomic status, literacy and education, health literacy and inequality. Risk factors for early onset of presbyopia included environmental factors, nutrition, near demands, refractive error, accommodative dysfunction, medications, certain health conditions and sleep. Presbyopia was found to impact on quality-of-life, in particular quality of vision, labour force participation, work productivity and financial burden, mental health, social wellbeing and physical health. Current understanding makes it clear that presbyopia is a very common age-related condition that has significant impacts on both patient-reported outcome measures and economics. However, there are complexities in defining presbyopia for epidemiological and impact studies. Standardisation of definitions will assist future synthesis, pattern analysis and sense-making between studies.

Abbreviations: BCVA, Best corrected visual acuity; CI, Confidence interval; DALY, Disability-adjusted life-years; eREC, Effective refractive error coverage; HIV, Human immune-deficiency virus; OR, Odds ratio,; PALY, Productivity-adjusted life years; PICQ, Presbyopia impact and coping questionnaire; PROMs, Patient-reported outcome measures; QALY, Quality-adjusted life years; REC, Refractive error coverage; UCVA, Uncorrected visual acuity; WHO, World health organization.

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Table 1
Prevalence of presbyopia in rural populations in population-based cross-sectional studies.

Authors, Date (Reference)	Country	NVA, reading distance	Sample size	Age (years)	Overall prevalence Percent (95 % CI)	Presbyopia in females Percent or Odds Ratio (95 % CI)	*Presbyopia in older age Percent or Odds Ratio (95 % CI)
Cheng et al., 2016 [30]	Mongolia	N8, 40 cm	5158	≥ 40	51.7 (46.5 – 54.9)	57.3 (56.2 – 59.6)	60.3 % for the ≥ 70 years‡
Marmamula et al., 2012 [48]	India	N8, customary distance	1094	≥ 40	45.2 (42.3–48.1)	NA	NA
Marmamula et al., 2021 [49]	India	N8, customary distance	4526	≥ 35	41.1 (39.0 – 42.5)	NA	NA
Malhotra et al., 2022 [22]	India	N8, customary distance	3246	≥ 35	42.9 (41.2 – 44.6)	**OR**, 1.5 (1.2 – 1.8)†	**OR**, 11.7 (8.6 – 15.9) for the 50 – 59 years compared to the 35 – 39 years †
Abdullah et al., 2015 [50]	Pakistan	N8, 40 cm	917	≥ 30	57.5 (NA)	55.2 % (NA)	NA
Lu et al., 2011 [27]	China	N8, 40 cm	1008	40–70	67.3 (64.3–70.1)	67.2 (63.4 – 70.8), NS	81.8 % for the 60–69 years ‡
Sadamatsu et al., 2021 [21]	Japan	N6, 30 cm	1156	≥ 40	26.4 (23.9–29.0)	**OR**, 1.4 (1.0 – 1.9)†	**OR**, 1.05 (1.0 – 1.1) older age†
Burke et al., 2006 [25]	Tanzania	N8, 40 cm	1709	≥ 40	61.7 (59.2 – 64.1)	**OR**, 1.5 (1.2 – 1.8)†	**OR**, 1.16 (1.1 – 1.2) per year between 40 and 50 years
Patel et al., 2006 [26]	Tanzania	N8, 40 cm	1562	≥ 40	62 (NA)	NA	NA
Umar et al., 2015 [29]	Nigeria	N8, 40 cm	635	≥ 40	30.4 (26.8 – 34.1)	2X higher than in males	3X higher for the ≥ 70 years than the 40 – 49 years
Obajolowo et al., 2016 [31]	Nigeria	N8, 40 cm	335	≥ 35	59.7 (NA)	42.5 %, NS	39.1 % for the 55 – 64 years
Uche et al., 2014 [28]	Nigeria	N8, 40 cm	585	≥ 35	63.4 (62.6 – 64.2)	**OR**, 1.1, NS	**OR**, 1.0 (p = 0.001) for older age
He et al., 2012 [7]	Nepal (Kaski)	N6, 40 cm	2157	≥ 35	59.7 (57.3 – 62.1)	55.5	86.8 % in 50–59 years
He et al., 2012 [7]	China (Shunyi)	N6, 40 cm	3554	≥ 35	41.9 (39.4 – 44.4)	47.8 %, NS	77.5 % in 50–59 years

customary working distance = approximately 35 – 40 cm distance, NVA = near visual acuity, NA = not available, CI = confidence Interval, OR = Odds ratio, NS = not significant, ≥ greater than and equal to, * the highest odds ratio in the given age group, † an adjusted value based on bivariate and multivariate analysis, ‡ the highest proportion in the given age group compared to all age groups.

1. Overall purpose

Epidemiological studies describe the distribution of disease, identify risk factors influencing distribution, and measure impacts. This knowledge is used to plan and evaluate strategies to prevent the development of disease and as a guide to the management of people in whom disease has already developed [1]. The purpose of this report is to review evidence on the epidemiology and impact of presbyopia and to provide recommendations for future needs and research opportunities. The specific goals of this report are to assess and summarise available evidence on the:

1. prevalence and factors influencing presbyopia and near effective refractive error coverage (near eREC)
2. impact of presbyopia and near eREC on patient-reported outcome measures (PROMs)
3. impact of presbyopia and near eREC on health economics

2. The prevalence and factors influencing presbyopia and near eREC

2.1. Definition of presbyopia

The definition of, and methods used to measure presbyopia, significantly impact its prevalence. As discussed in the BCLA CLEAR Presbyopia: Evaluation and diagnosis report[2], at one end of the spectrum, a clinical approach may define presbyopia as symptomatic loss of accommodation with age after any distance refractive error has been corrected [3]. This requires cycloplegic distant refraction (for certainty of fully relaxed accommodation) and correction of any refractive error found, then (without cycloplegia) testing near vision at the required working distance, and then correcting that with an appropriate near addition before retesting near vision. At the other end of the spectrum, an epidemiological study protocol might, after measuring pinhole distant vision, simply test unaided near vision and classify anyone who can resolve a specified threshold acuity as "non-presbyopic" and anyone who cannot as "presbyopic" [3]. The latter methodology and definition would mean that people with a useful amount of myopia would never be classified as presbyopic, unlike when using the former methodology which would. There are several options between these extremes, and each may influence the prevalence of presbyopia. The definition used in this paper is based on that presented in the BCLA CLEAR Presbyopia: Definitions report [4]: *Presbyopia occurs when the physiologically normal age-related reduction in the eye's focusing range reaches a point that, when optimally corrected for distant vision, the clarity of vision at near is insufficient to satisfy an individual's requirements* [5,6].

2.2. Presbyopia determination

Despite the battery of tests used to measure accommodation (see BCLA CLEAR Presbyopia: Evaluation and diagnosis report) [2] there is no standardised test(s) to diagnose presbyopia for epidemiological purposes. The protocol developed around 2010 under the auspices of the World Health Organization (WHO) and United States National Institutes of Health is perhaps the clearest and most widely adopted protocol [7,8]. However, variations in presbyopia definition and ascertainment were common pre-2010, and still occur, affecting the measurement of its prevalence. For example, the endpoint chosen (target visual acuity) and the distance at which near vision is tested can influence the result [9].

Three criteria have commonly been used to define presbyopia in epidemiological studies: 1) participants are unable to read N8 optotypes with distant correction in place, if needed; 2) participants are able to improve two or more lines with the addition of plus lenses up to the established target of N8 [9], and 3) participants require a dioptric threshold (such as ≥+1.00 dioptre of addition) to resolve the near vision target [10–15].

Epidemiologically-measured presbyopia should be based on the best technical guidance for clinical diagnosis, and report a) age, b) testing

Table 2
Prevalence of presbyopia in urban populations in population-based cross-sectional studies.

Authors, Date (Reference)	Country	NVA, reading distance	Sample size	Age (years)	Overall prevalence Percent (95 % CI)	Presbyopia in female Percent or Odds Ratio (95 % CI)	*Presbyopia in older age Percent or Odds Ratio (95 % CI)
Kidd Man et al., 2016 [12]	Singapore	N8, 40 cm	7890	40 – 86	33.9 (uncorrected)	**OR,** 1.14 (1.01 – 1.3)†	NS
Han et al., 2018 [24]	China	N6, 40 cm	1191	≥ 35	25.2 (21.5 – 28.9)	25.1 (22.3 – 27.9), NS	50.4 % (37.1 – 63.8) for the ≥ 65 years ‡
He et al., 2012 [7]	China (Guangzhou)	N6, 40 cm	1817	≥ 35	53.3 (50.3 – 56.4)	49.3 %	75.1 % in 50–59 years
Srinivasan et al., 2021 [15]	India	NA, 35 – 40 cm	1128	≥ 40	79.8 (77.5 – 81.8) in non-diabetic adults	**OR,** 10.4 (1.6 – 65.7)†	OR < 1, for older age, NS†
Hashemi et al., 2012 [11]	Iran	N8, 40 cm	5190	40 – 64	58.2 (56.5 – 59.8)	59.2 (57.2 – 61.2)	83.3 % for the 60 – 64 years‡
Mashayo et al., 2015 [51]	Tanzania	N8, 40 cm	1663	≥ 35	46.5 (44.3 – 48.7)	NA	**OR,** 19.8 (11.8 – 33.2) for the 70 – 74 years compared to the 35 – 39 years
Naidoo et al., 2013 [52]	South Africa	0.3 LogMAR, 40 cm	1939	≥ 35	77 (74.3 – 79.2)	**OR,** 1.2 (0.9 – 1.6), NS	**OR,** 3.2 (2.3 – 4.3) for 50 – 64 compared to 35 – 49 years
Seidu et al., 2016 [13]	Nigeria	N8, 40 cm	440	≥ 40	75.0 (70.9 – 79.0)	76.3 %	87.4 % in ≥ 50 years
Agboola et al., 2022 [53]	Nigeria	N8, 40 cm	255	≥ 30	67.3 (NA)	**OR,** 0.92 (0.9 – 1.3), NS†	**OR,** 29.97 (10.2 – 81.9) for the ≥ 50 years compared to the 30 – 39 years †
He et al., 2012 [7]	Niger (Dosso)	N6, 40 cm^	2045	≥ 35	37.5 (33.8 – 41.1)	30.8 %	47.3 % in 50–59 years
He et al., 2012 [7]	USA (Latino in Los Angeles)	N6, 40 cm	663	≥ 35	61.1 (57.2 – 65.1)	69.8 %	85 % in 50–59 years
Casas Luque et al., 2019 [54]	Colombia	N8, 40 cm	2886	≥ 35	55.2 (52.9 – 57.4)	**OR,** 1.2 (0.95 – 1.4), NS	**OR,** 80.6 (43.7 – 148.8) for the ≥ 75 years compared to the 35 – 44 years †
Duarte et al., 2003 [55]	Brazil	N4, 37 cm	3007	≥ 30	54.7 (NA)	59.3 (NA)	93.1 % for > 60 years

≥ greater than and equal to, * the highest odds ratio in the given age group, † an adjusted value based on bivariate and multivariate analysis, ‡ the highest proportion in the given age group compared to all age groups,^vision testing completed outside in bright sunlight (Dosso only).

distance, c) visual performance without the addition and, d) visual performance with the addition [16,17,5]. Results should be disaggregated for age, urbanisation level, and sex. Table 1, Table 2 and Table 3 provide a summary of relevant prevalence studies.

Although Table 1, Table 2 and Table 3 suggest that there is some consensus in how studies should be conducted, there are still differences that are likely to impact the reported prevalence. For example, some studies mention testing under “normal indoor illumination”, but most fail to give details of the lighting conditions which can make a significant difference for presbyopia prevalence [18–20]. In addition, near vision is tested typically 40 cm away from the participant, but distances between 30 and 35 cm have also been used [21,22]. Shortening the test distance by as little as 5–7 cm is likely to indicate increased prevalence and a younger age of presbyopia onset. Some studies failed to correct distance astigmatism that can also cause significant inaccuracies for determining the near addition [13]. Some studies define “functional presbyopia” in a way that is vague [23,24], for example, stating “with the use of a plus lens”, without specifying a defined lens power [23,24]. There is also some variation in how age is used as an inclusion criterion for presbyopia detection [25–31,21], for example, recruiting individuals aged 35 years and above, or 45 years and above, rather than 40 years and above which is the most referenced age criteria [32–35]. These relevant but specific aspects of testing are described in detail in the BCLA CLEAR Presbyopia: Evaluation and diagnosis report [2].

While presbyopia is a normal age-related change, presbyopia-like signs and symptoms arising from conditions such as accommodative insufficiency and/or accommodative infacility can be present at almost any age [36]. The need for near specific addition is occasionally linked to other vision issues, systemic health problems, or syndromes, such as familial amyloidosis [37], or medications [38–40] which impact the crystalline lens (see Section 2.6.6.6). Age also leads to smaller pupils (miosis) that increase the depth of focus and that can, to some extent, counteract the blur caused by the impaired accommodation mechanism [41,42]. Variable pupil sizes also add challenges to the optical correction of presbyopia with, for example, multifocal contact lenses or multifocal intraocular lenses (see BCLA CLEAR Presbyopia: Management with contact lenses and spectacles / intraocular lenses reports) [43,44 45,46]. In line with this, someone who transiently uses medication that affects accommodation or pupil size might feel like they have presbyopia [38–40,45]. Conversely, changing from reading indoors with artificial light to outdoors with natural bright daylight can change the pupil size and retinal illumination and consequently reduce the symptoms of presbyopia [47]. Therefore, the ascertainment or diagnosis of presbyopia can be relatively challenging, and a clear definition of inclusion and exclusion criteria, a combination of tests and clinical variables, as well as test conditions, is required to standardise findings and enable meaningful comparisons. Detailed methods to diagnose and correct presbyopia are covered in the BCLA CLEAR Presbyopia: Evaluation and diagnosis report [2].

2.3. *Prevalence of presbyopia*

The global all-ages prevalence of epidemiologically-measured functional presbyopia (that is *not including* people with useful myopia) was estimated at 24.9 % (95 % confidence interval [CI], 23 % – 27 %) in 2015, affecting 1.8 billion people (95 % CI, 1.7 – 2.0 billion) [3]. This prevalence was projected to stabilise at 24.1 % in 2030 due to increasing myopia, but to affect more people (2.1 billion) due to population dynamics [3].

Using the same methodology but changing to the definition of BCLA CLEAR Presbyopia: Definitions report [4] (that is *including* people with all types of distant refractive error), the global all-ages prevalence of presbyopia was estimated at 31.7 % (95 % CI, 30 % – 34 %) in 2015, affecting 2.3 billion people (95 % CI, 2.2 – 2.4 billion). The prevalence is projected to increase to 36.6 % (affecting 3.1 billion people) in 2030 [62].

Regional differences in the prevalence of presbyopia arise mainly from the balance between minor differences in the relationship between

Table 3
Prevalence of presbyopia in mixed population (urban and rural) in population-based studies.

Authors, Date (Reference)	Country	NVA, reading distance	Sample size	Age (years)	Overall prevalence percent (95 % CI)
Brian et al., 2011 [56]	Fiji	N8, 40 cm	1381	≥ 40	64.4 (NA)
Marmamula et al., 2011 [33]	India	N8, customary distance	3095	35 – 49	63.2 (60.2 – 66.2)
Nirmalan et al., 2006 [10]	India	N8, customary distance	5587	30 – 70	55.3 (54.0 – 56.6)†
He et al., 2012 [7]	India (Tamil Nadu)	N6, 40 cm	2630	≥ 35	60.3 (57.2 – 63.3); female prevalence was 57.7 %; and prevalence was 63.1 % in 50–59 years
Ramke et al., 2012 [53]	Timor Leste	N8, 40 cm	2014	≥ 40	52.5 (NA); female prevalence was 53.8 %; and prevalence was 65.1 % in 50–69 years
Kimani et al., 2013 [57]	Kenya	N8, 40 cm	3627	35 – 75	25.1 (22.05 – 28.45)
Bastawrous et al., 2013 [58]	Kenya	N8, 40 cm	3993	≥ 50	92.3 (90.4 – 93.9)
Chan et al., 2013 [59]	Eritrea	N6, 40 cm	3171	35 – 50	32.9 (30.3 – 35.7)
Muhit et al., 2018 [60]	Bangladesh	N8, customary distance	1402	≥ 35	62 (59.4 – 64.5)
Senyonjo et al., 2014 [61]	Nigeria	N8, 40 cm	3899	35 – 75	54.1 (50.6 – 57.6)
Cunha et al., 2018 [34]	Brazil	N8, 40 cm	2025	≥ 45	71.8 % (NA)

NVA V = near visual acuity, NA = not available, CI = confidence Interval, NS = not significant.
≥ greater than and equal to, † an adjusted value based on bivariate and multivariate analysis.

age and amplitude of accommodation, and more significant differences in age profiles between regions [3]. In terms of epidemiologically-measured functional presbyopia, the lowest prevalence is in Central Africa (13.4 %) and the highest is Western Europe at 39.0 % [3]. In terms of the BCLA CLEAR Presbyopia: Definitions report definition [4], regional prevalence ranges from 14.7 % (Central Africa) to 47.0 % (Western Europe).

Regional differences in the prevalence of uncorrected presbyopia are more marked and are covered in Section 2.5.

2.4. Near eREC definition and determination methodology

eREC is defined as the proportion of the population that has received the needed refractive correction with a good-quality outcome. The term eREC was introduced in 2019 as an update on the previously used term 'refractive error coverage' (REC). REC only considered if individuals that needed refractive correction were optically corrected, without a measure of vision improvement [63]. eREC, however, assesses if individuals that receive refractive corrections do so with adequate quality by adding visual acuity measurements [63]. The initial method for near eREC determination was based on the measurement of near presenting visual acuity with refractive correction, however this method overestimated the true near eREC [8]. Hence, in 2021 a new method of near eREC was introduced that includes measures of both near uncorrected visual acuity (UCVA) and near presenting visual acuity. The latest revision of the international classification of disease (ICD-11) defines near vision impairment as including near presenting visual acuity of worse than N6 [64].

As the Vision 2020 – Right to Sight program concluded in 2020, WHO member States endorsed the adoption of a new resolution titled 'Integrated people-centred eye care, including preventable vision impairment and blindness'. The resolution sets new targets on two global eye care indicators by the year 2030, one of which is the near eREC. In 2021, the World Health Assembly endorsed a new target of a 40 % increase in near eREC by 2030 [65,66].

The flow chart in Fig. 1 depicts the visual acuity measurements required to categorise near eREC at an individual level [67]. Table 4 describes the recommended calculation method for near eREC [65]. The estimation of near eREC requires data on both met and unmet needs for refractive correction. The met need for distant vision is defined as individuals with UCVA worse than 6/12 in the better eye with correction (by the means of spectacles, contact lenses or refractive surgeries) and presenting visual acuity of equal to or better than 6/12. Unmet needs meanwhile are described as individuals with presenting visual acuity worse than 6/12 who could improve to better than 6/12 visual acuity with pinhole [65,68]. While these criteria have been well established for distant vision, a lack of a universal method to measure near visual acuity has made a similar translation to near vision difficult. A wide range of formats (text versus letters), fonts, font sizes and testing distance have been used to determine the prevalence of both corrected and uncorrected near vision (see BCLA CLEAR Presbyopia: Evaluation and diagnosis report) [2]. A standardised protocol for near vision assessment was introduced to deal with these inconsistencies which recommends the use of Times New Roman font with font size N6 or N8 at viewing distance of 40 cm to assess near vision [69].

Based on these recommendations, the met needs for near eREC can be defined as UCVA worse than N6 at 40 cm in the better eye and presenting visual acuity equal to or better than N6 with near correction [65,68]. The unmet need meanwhile refers to UCVA less than N6 in the better eye in the absence of near correction and distant vision best corrected visual acuity (BCVA) equal to or better than 6/12. Another category that is recommended for near visual acuity is individuals with undermet needs (Fig. 1); corrected near presenting visual acuity worse than N6 and distant BCVA equal to or better than 6/12 in the better eye. The rationale for the inclusion of distant vision (6/12) for the near unmet and undermet need is to exclude individuals who have non-optical conditions decreasing vision at all distances, including cataract, corneal scarring or macular disease.

2.5. Prevalence of near eREC

The need for near vision corrections has been growing due to the increasing population of older individuals worldwide [70]. While population-based studies provide important data on near eREC from a certain geographical region in a specific time period, *meta*-analyses with modelling methods help to explore global trends and predict future projections. However, the relative lack of reliable population-based data and standardised criteria for assessment and diagnosis has made the determination of the prevalence of uncorrected near vision and near eREC difficult [7].

Several studies have assessed near visual impairment, defined as near visual acuity less than N6 (or equivalent, 6/12 Snellen, 0.3 LogMAR) at 40 cm. A seven-site study across six countries between 2008 and 2009 assessed 14,805 adults over 35 years of age and reported near

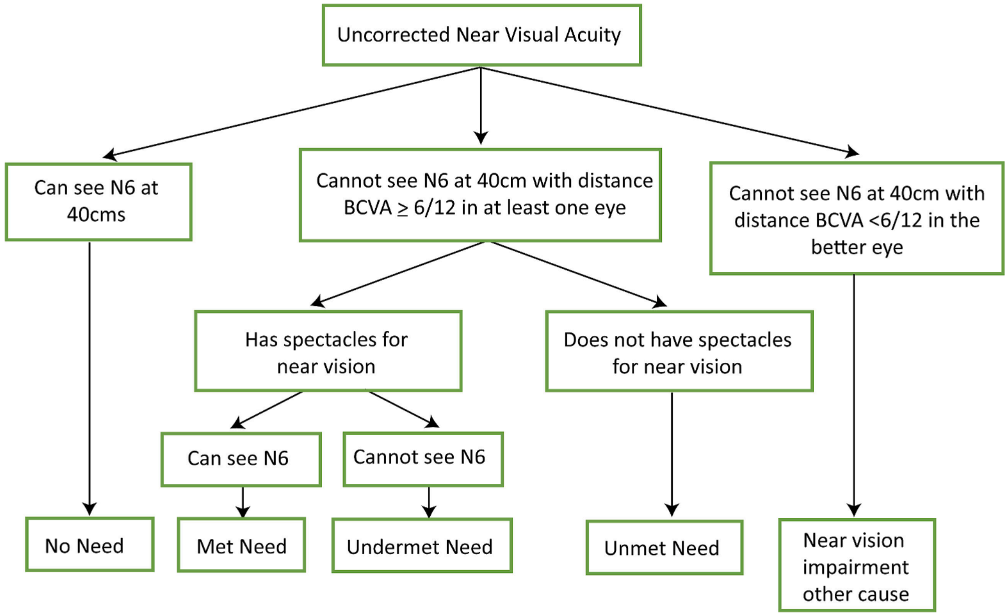

Fig. 1. Flow chart depicting the visual acuity measurements required to categorise individuals as having no need, met need, undermet need and unmet need in the context of calculating effective coverage of refractive error (for near vision). Based on near visual acuity in the better eye, adopted from Keel et al [65]).

Table 4
Recommended calculation method for near vision refractive error coverage as documented by Keel et al [65].

Near vision effective refractive error coverage = 100 × [a/(a + b + c)]
a = individuals with UCVA worse than N6 at 40 cm in the better eye who present with spectacles for near vision and whose presenting visual acuity is equal or better than N6 in the better eye *(met need)*;
b = individuals with distant vision best corrected visual acuity (BCVA) equal or better than 6/12* in at least one eye who present with spectacles for near vision and whose presenting visual acuity is worse than N6 in the better eye *(undermet need)*;
c = individuals with distant vision BCVA equal or better than 6/12 in at least one eye who do not have correction for near vision and whose UCVA is worse than N6 in the better eye *(unmet need);*
UCVA = uncorrected visual acuity; if spectacles or contact lenses are worn to the assessment, visual acuity is measured with the person not wearing them.
BCVA = best-corrected visual acuity; visual acuity is assessed either by pinhole or refraction.
*Only individuals with distant vision BCVA equal or worse than 6/12 will be considered to exclude those with reduced near vision not due to other causes.

uncorrected visual impairment ranged between 49 % in Dosso, Niger, to 83 % in Madurai, India, and Durban, South Africa [7,8]. It should be noted that measurements were performed outside in Dosso due to unreliable indoor lighting, so this estimation likely under-represents the potential impairment experienced indoors or at night. All other sites performed measurements under standard, bright, indoor illumination.

The near met needs ranged from 0.12 % in Shunyi, China; 1.61 % in Durban, South Africa to 66.3 % in Los Angeles, USA [7,8]. These translate to near eREC of 0.2 % in Shunyi, China; 2.3 % in Durban, South Africa; and 75.2 % in Los Angeles, USA. In a study from Telangana, India ($n = 5357$, ≥ 40 years of age), the prevalence of near visual impairment was 55.8 % with near eREC of 31.8 % [49]. Another study from rural China reported that 78.1 % of 1008 participants had uncorrected near visual impairment [27]. Yet another study from Brazil reported that 81.1 % among 2025 participants over the age of 45 years had near visual impairment [34]. The near visual impairment reduced to 20.5 % after near refractive correction [34]. In a study from Trinidad and Tobago ($n = 3589$, ≥ 40 years of age), 22.3 % had near visual impairment based on presenting visual acuity with near eREC of 44.7 % [71].

A *meta*-analysis estimated that in 2015 around 826 million (686 – 960 million), out of the 1.8 billion people needing near correction, had uncorrected near visual impairment [3]. This gives a global all-ages near eREC of 54 %. Regional differences were dramatic, with unmet need for near refractive corrections varying from close to zero in high income countries to around 90 % in Central Africa. A Global Burden of Disease update using the same methodology estimated that in 2020 around 510 million (371 – 667 million) adults aged 50 years and over had uncorrected near visual impairment (near presenting visual acuity worse than N6 or N8 at 40 cm) [72,73]. This represents around 22.1 % of people 50 years of age and above worldwide [73]. The same study also predicted around 866 million (629 to 1150 million) will have uncorrected near vision by 2050 [73]. Overall, refractive error causes more vision impairment at near than in the far distance, with estimates that the prevalence of uncorrected near vision could be as high as 6 times larger than that for uncorrected distant vision [3]. The global near eREC for 2021 was reported to be around 20.5 % for adults over 50 years of age, significantly lower compared to distant eREC of 42.9 % [68].

The differences in the pooled prevalence of uncorrected near visual impairment and near eREC from different *meta*-analyses and systematic reviews could be due to the differences in the study methodologies including age criteria. The results from both population-based studies and systematic review/*meta*-analyses show that near eREC varies across geographical regions [3]. Other factors that influence near visual impairment and near eREC include age, location, sex, and educational status.

2.6. *Factors influencing prevalence of presbyopia and near eREC*

2.6.1. *Age*

The prevalence of presbyopia is known to increase with age [11,28,30,13,3]. In rural China, the prevalence increased from 27.6 % at the age of 40 – 49 years to 81.8 % at the age of 60 – 69 years ($p < 0.001$, $n = 1008$) [27]. In rural India, the prevalence of uncorrected presbyopia showed an increasing trend (adjusted odds ratio [OR], 11.7; 95 % CI, 8.6

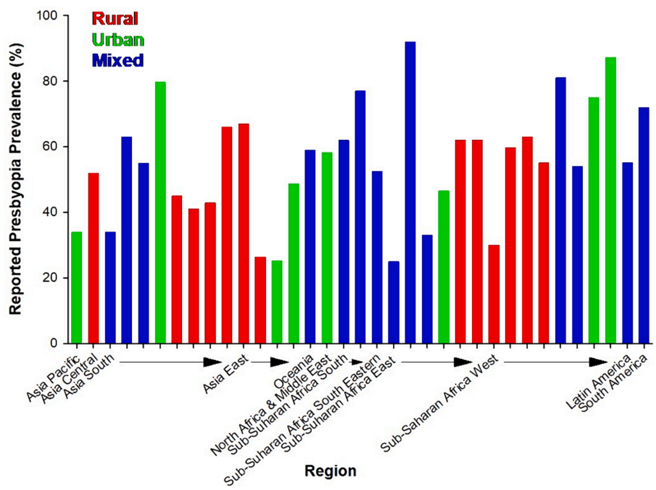

Fig. 2. Regional differences in the prevalence of presbyopia in urban, rural and mixed settings in population-based studies [25,26,56,27,11,58,59,57,52,28,51,29,30,12,31,34,24,60,54,75,21,15,53].

Table 5
List of drugs with potentially anticholinergic side effects.

Drug class	Mechanism	Examples
Phenothiazines (antipsychotic agents)	Phenothiazines block postsynaptic neurotransmission by binding to dopamine, muscarinic, histamine and serotonergic 5-hydroxytryptamine 2 receptors [129].	Chlorpromazine (Largactil)
Antihistamines	Many first-generation antihistamines are derivatives of phenothiazines, which can lead to atropine-like anticholinergic effects [128,127].	Promethazine (Phenergan)
Tricyclic antidepressants	Inhibit the activity of histamine, 5-hydroxytryptamine and acetylcholine [127]	Imipramine (Tofranil) and amitriptyline (Endep)
Selective serotonin reuptake inhibitors (antidepressant or anti-anxiety)	Selective inhibitor of 5-hydroxytryptamine uptake. Antagonism of muscarinic receptors can lead to anticholinergic effects [127]	Fluoxetine (Prozac) or paroxetine (Aropax)

– 11.9, n = 608) in the age range of 50–59 years compared to that in the age range of 35–39 years (n = 663) [22]. Similarly, the prevalence of uncorrected presbyopia was 3.2 times (95 % CI, 2.3 – 4.3; n = 686) higher in adults aged 50 – 64 years compared to that in adults aged 35 – 49 years (n = 587) in South Africa [52]. In rural Japan, the prevalence of uncorrected presbyopia was not associated with old age (adjusted OR, 1.05; 95 % CI = 1.03 – 1.07; n = 1156) [21]. In comparison in Colombia, the unadjusted OR ranged from 12.4 (95 % CI, 8.7 – 17.6; n = 590) in adults aged 45–54 years to 80.6 (95 % CI, 43.7 – 148.8; n = 196) in adults aged ≥ 75 years compared to adults aged 35 – 44 years (n = 369) [54]. There were some contradictions noted in the proportion of presbyopia at older ages across different studies, mostly due to definition differences such as whether distant refractive error should be corrected or not. However, the known physiology of accommodation and the balance of published findings support the premise that presbyopia increases with age (see BCLA CLEAR Presbyopia: Mechanism and optics report) [74].

Near visual impairment is also associated with increasing age. In a multi-site study, around 50 % of participants between 35 and 39 years of age had near visual acuity worse than 6/12 in Madurai, India and Durban, South Africa [7]. By the age of 50, 89.6 % in Madurai, India and 94.8 % in Durban, South Africa had near visual acuity worse than 6/12 [7]. The study also reported an increasing prevalence of uncorrectable near visual impairment (that is despite best refractive correction) in older age groups (≥55 years of age) [7,8]. Similar results of higher near visual impairment in older age groups based on presenting visual acuity have also been reported in Brazil where the prevalence of near visual impairment was 94.5 % in those ≥ 75 years of age compared to 77.9 % among 45 – 54 years of age [34].

Near eREC has been reported to increase from 47.4 % among those aged 30 – 49 years of age to 75.7 % in those ≥ 70 years of age in Los Angeles, USA [7,8]. Small increases have also been observed in Kaski, Nepal (4.1 % to 5.3 %), Madurai, India (4.0 % to 10.88 %) and South Africa (0.5 % to 4.3 %) [7,8]. Other regions showed a small reduction in near eREC with age: in Trinidad and Tobago (43.1 % in 30–49 years and 41.4 % in ≥ 70 years) and Shunyi, China (1.4 % in 30 – 49 years and 0.2 % in ≥ 70 years) [68]. While distant eREC declines with age in people over 50 years of age, this pattern is not clear for near eREC due to limited data [68].

2.6.2. *Geographic location*

Presbyopia prevalence data were obtained for Asia (Central, Pacific, South, East, Southeast), Oceania, Latin America (Central), North America, North Africa-Middle East, and Sub-Saharan Africa (Eastern, Southern, Western) regions [25,26,56,27,11,58,59,57,52,28,51,29,30,12,31,34,24,60,54,75,21,15,53]. All the population-based studies were grouped based on their geographical location and plotted in Fig. 2. The prevalence of presbyopia was higher in urban compared to rural populations (see Section 2.6.3). Many studies have been conducted in the Sub-Saharan African regions, hence more prevalence data were available in these regions compared to other regions. Additional details are provided in Tables 1-3.

The prevalence of both near visual impairment and near eREC varies based on the geographical location, economic status, and urban and rural setting. Areas with lower economic status and rural setting experience higher burden of uncorrected near vision due to lower near eREC [3].

The prevalence of unmet need for near eREC was almost zero in high income regions (that is North America, Asia Pacific, Western Europe, and Australasia), while the largest unmet need was around 90 % in Western, Eastern, and Central sub-Saharan Africa [3]. Meanwhile, the highest number of people with uncorrected near vision lived in South Asian regions (around 275 million) [3]. In terms of near eREC, the high-income countries had the highest near eREC (64.7 %), followed by north Africa and Middle East (41.8 %), Latin America and Caribbean (15.5 %), South Asia (3.3 %), and sub-Saharan Africa (1.4 %) [68]. Among different countries and locations with good quality data, near eREC varied based on the geographical location and economic conditions. The highest near eREC reported was 87.4 % in Los Angeles, USA [7]; followed by 52.6 % in Trinidad and Tobago [71] and 31.4 % in Parintins, Brazil [76,68]. The lowest near eREC was reported was 0.3 % for Tripura, India [75] and 0.5 % for Shunyi, China [7]. Other areas with reliable near eREC data include Durban, South Africa (5.6 %), Madurai, India (6.8 %) and Kaski, Nepal (8.8 %) [7].

2.6.3. *Urban versus rural locations*

Greater prevalence of presbyopia has been reported in urban populations compared to rural populations (Fig. 2), although the variation is far greater than the difference. In rural populations the prevalence of presbyopia varies between 26–67 % (Table 1) while that in urban populations ranges between 25–80 % (Table 2).

The effect of an urban versus rural setting has also been extensively explored in relation to near visual impairment and near eREC. Rural residence was associated with higher prevalence of uncorrected near visual impairment in Brazil [34]. In contrast, in urban areas of Los Angeles (USA) and Guangzhou (China), around 60 % of those needing near vision correction were already corrected to near visual acuity better

Table 6
Examples of various types of quality-of-life (QoL) measures used in presbyopia.

Type of QoL measures	Examples
Presbyopia-specific	Near Activity Visual Questionnaire (NAVQ) [155], Near Vision-related QoL questionnaire (NVQL) [26], Freedom from Glasses Value Scale (FGVS) [154], Presbyopia Impact and Coping Questionnaire (PICQ) [156], Near Vision Presbyopia Task-based Questionnaire (NVPTQ) [157], and Activities of Daily Living (ADL) framework [161].
Non-presbyopia-specific	**Refractive error-specific:** National Eye Institute Refractive QoL (NEI-RQL) [162,163], Refractive Status and Vision Profile (RSVP) [164], Refractive Error Item Banks [165] **Cataract-specific**: Catquest questionnaire [166,167] **Dry eye-specific:** OSDI [168] **Ophthalmic non-disease-specific**: Quality of Vision [169,167,170], National Eye Institute Visual Function Questionnaire(NEI-VFQ) [171–174], Digital Eye Strain Questionnaire (DESQ) [175], Visual Function (VF) questionnaire [170], **Non-ophthalmic**: Akman modified QoL (AQOL) Questionnaire [176]

than N6.

In one study conducted in six low- to middle-income countries, air pollutants ($PM_{2.5}$ and O_3) correlated with presbyopia prevalence [77]; countries where high concentration of the aforementioned air pollutants was observed, showed double the presbyopia prevalence [77].

In a *meta*-analysis, the effect of the rural versus urban setting was only significant in countries with a low and medium human development index (≤0.70) [3]. In these countries, people residing in urban settings had better near eREC [3]. This effect was not observed for countries with a higher human development [3]. Hence the difference in the prevalence of near visual impairment and near eREC between rural and urban settings could be attributed to economic conditions rather than the rural versus urban setting per se. However, these results are based on limited data and further research is needed to better understand these differences.

2.6.4. Sex

Prevalence of presbyopia has been reported to be higher in females than in males of the same age group [25,10,11,59,52,60,54]. This has been confirmed in a systematic review, with women over 40 years of age having a higher prevalence of presbyopia than men in the same age group (OR, 1.19; 95 % CI, 1.02 – 1.45) [78]. In population-based cross-sectional studies, the OR for the prevalence of presbyopia in females was 1.14 (95 % CI, 1.01 – 1.3, n = Male: Female = 3981: 3909) in Singapore, 1.4 (95 % CI, 1.0—1.9, Male: Female = 487: 669) in Japan, and 1.5 (95 % CI, 1.2 – 1.8, Male: Female = 1508: 1738) in India [12,21,22]. Overall, the increased prevalence of presbyopia for women was hypothesised to be caused by differences in tasks performed and viewing distances, rather than physiological sex differences in accommodative mechanisms [78].

Some studies have reported sex as a factor in the prevalence of uncorrected near visual impairment and near eREC. A *meta*-analysis in 2020 reported higher prevalence of near visual impairment among females when compared to males [73]. However, another *meta*-analysis reported the opposite: that overall, women had higher near eREC compared to men [68]. While sex may be a factor explaining some variance in uncorrected near visual impairment and near eREC, the effect of sex appears minor in most locations, and could go in either direction depending on local factors affecting access to care [68].

2.6.5. Other factors which impact prevalence

Age (covered in Section 2.6.1) is the single strongest determinant of the prevalence of presbyopia. Location (including regional and country effects, altitude, temperature, ultraviolet light exposure, and urbanisation effects), and sex have been shown to have some effects. There are a range of other factors that *may* have some effects on presbyopia prevalence, but their influence is difficult to distinguish from confounding factors. These factors will have a stronger effect on near eREC.

2.6.5.1. Socioeconomic status. Socioeconomic status is linked to several factors that could influence presbyopia prevalence, including refractive error, diet, ultraviolet radiation exposure, air pollution, and rates of systemic disease [79–81]. No studies reliably distinguish between a

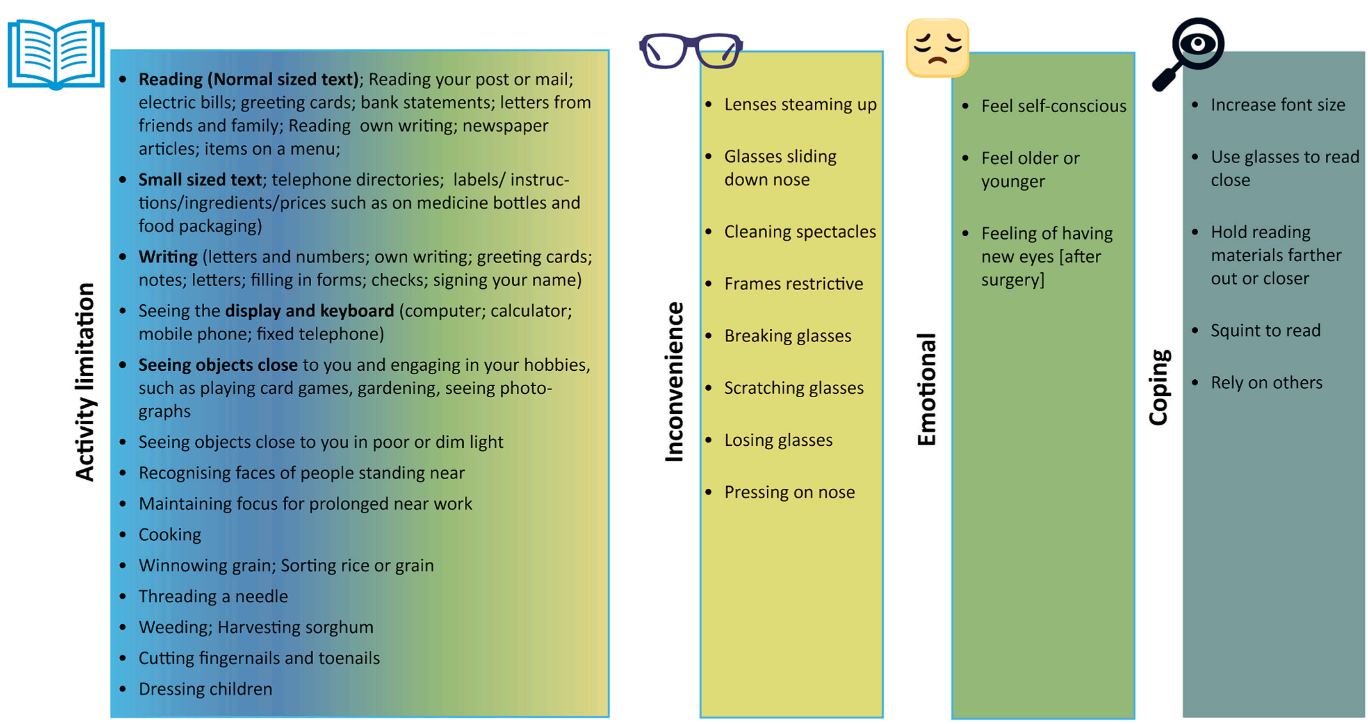

Fig. 3. Examples of quality-of-life domains and issues in presbyopia-specific patient-reported outcome measures (PROMs).

Table 7
Examples of quality of life issues in the presbyopia-specific patient-reported outcome measures (PROMs) [177–179,169,180–184,5,170,185].

Activity limitation	Reading (normal sized text) Reading post/mail, such as electric bills, greeting cards, bank statements, letters from friends and family; Reading own writing, newspaper articles, items on a menu; Reading small sized text: telephone directories, labels/ instructions/ingredients/prices, such as on medicine bottles, food packaging) Writing (letters and numbers, greeting cards, notes, letters, filling in forms, checks, signing name) Seeing the display and keyboard on a computer or calculator, on a mobile or fixed telephone) Seeing nearby objects and engaging in hobbies, such as playing card games, gardening, seeing photographs Seeing nearby objects in poor or dim light Recognizing faces of people standing nearby Maintaining focus for prolonged near work Cooking Winnowing grain Sorting rice or grain Threading a needle Weeding Harvesting sorghum Cutting fingernails and toenails Dressing children
Inconvenience	Lenses steaming up Frames sliding down nose Cleaning spectacles Frames restrictive Breaking spectacles Scratching spectacles Losing spectacles Frames pressing on nose
Emotional	Feeling self-conscious Feeling older or younger Feelings of having new eyes [after surgery]
Coping	Increase font size Use spectacles to read close Hold reading materials farther out or closer Squint to read Rely on others

direct socioeconomic effect on presbyopia prevalence compared to a confounded effect from an associated factor. For example, elevated blood glucose decreases amplitude of accommodation, leading to earlier presbyopia onset in people with diabetes compared to aged-matched non-diabetic controls [82–86]. Diabetes is a common systemic disease, with prevalence variations that follow socioeconomic patterns mainly due to diet (high quality, low glycaemic-index food is generally more expensive) and exercise opportunities (such as safety of public spaces and gym memberships) [87,88]. The combination of high prevalence of diabetes, relation to socioeconomic factors, and the effect on accommodation, mean that diabetes could impact presbyopia prevalence between and within countries; hence the effect could align with socioeconomic factors.

Another socioeconomic aspect that might impact presbyopia prevalence is the type of work performed by the population assessed. Office-type work, associated with higher socioeconomic status, may be protective by decreasing exposure to ultraviolet radiation and air pollution, but conversely might exacerbate symptoms due to near vision demands [89,90]. Industrial and/or outdoor work, associated with lower socioeconomic status, may increase exposure to air-pollution, temperature variations and ultraviolet radiation [91]. These exposures might accelerate the oxidative stress associated with crystalline lens hardening [92,74] as found clinically [93], which might lead to earlier presbyopia onset [90], fitting socioeconomic patterns.

2.6.5.2. Literacy and education attainment. Any direct effect from literacy and educational attainment is likely to be outweighed by associated factors. For example, literacy and educational attainment are more likely to lead to indoor jobs and lower lifetime ultraviolet radiation exposure, which may delay presbyopia onset [94,95]. Literacy and education are also associated with increasing myopia, which can affect presbyopia prevalence because refractive error status affects the accommodation demand [96–100], decreasing the need for near correction when unaided.

The overall balance of direct and indirect effects appears to increase the prevalence of presbyopia with increases in education level [22 34].

Near visual impairment was higher among those who were not educated in India [49] and Brazil [34]. Similarly, another multi-site study reported that a higher rate of near visual impairment was associated with lower educational levels in Kaski, Nepal; Los Angeles, USA; and Durban, South Africa [7,8]. However, the study also reported a lower prevalence of near visual impairment in those with lower educational level in Dosso, Niger and no significant correlation between near visual impairment and educational level in Madurai, India; and Shunyi and Guangzhou, China [7,8]. Lower educational levels were also associated with a higher prevalence of uncorrectable near visual impairment (despite best refractive correction in those $\geq$ 55 years of age) in Shunyi and Guangzhou (China), Kaski (Nepal), and Madurai (India) [8].

Higher met needs for near vision correction were associated with better educational status in Brazil [34] and Singapore [12]. However, a study from rural China reported no significant association of near met needs with education level [27].

2.6.5.3. Health literacy. According to the new *Healthy People 2030* definitions of the United States Department of Health and Human Services, "personal health literacy is the degree to which individuals have the ability to find, understand, and use information and services to inform health-related decisions and actions for themselves and others" [101]. Health literacy is strongly related to both socioeconomic status and educational attainment in most countries [102]. It is the most likely conduit linking literacy and educational attainment with near eREC: there is no inherent reason that low education levels will cause low near eREC, but it is likely that low education would make it more difficult to understand health and health systems. However, while literacy and education have clearly measurable and universally recognised categories (such as completed elementary school/ high school/ tertiary education), health literacy does not. For this reason, there is no direct evidence linking health literacy and near eREC.

Rural areas generally have lower health literacy and thus more uncorrected near vision [103,28,104,22]. However, even in developed countries where health literacy is high, the quality of life for presbyopic individuals remains low due to challenges in obtaining optimal correction of their near vision [105]. Better health education on presbyopia and correction methods is crucial in both literate and illiterate individuals to advance quality of life [104].

2.6.5.4. Inequality. Inequality describes the uneven distribution of resources, knowledge and power throughout a community [106]. Two different locations with the same average wealth could have a very different spread of wealth [107]. No reports linking inequality and presbyopia prevalence were found.

However, it does seem plausible that inequality could result in some groups in a community achieving higher near eREC than others. Modelling of global systematic review near eREC data suggest that near eREC decreases as the Gini coefficient (an estimate of inequality) [108] increases [3]. That is, inequality does more than make some members of a community worse off – it actually makes the average worse off, in near

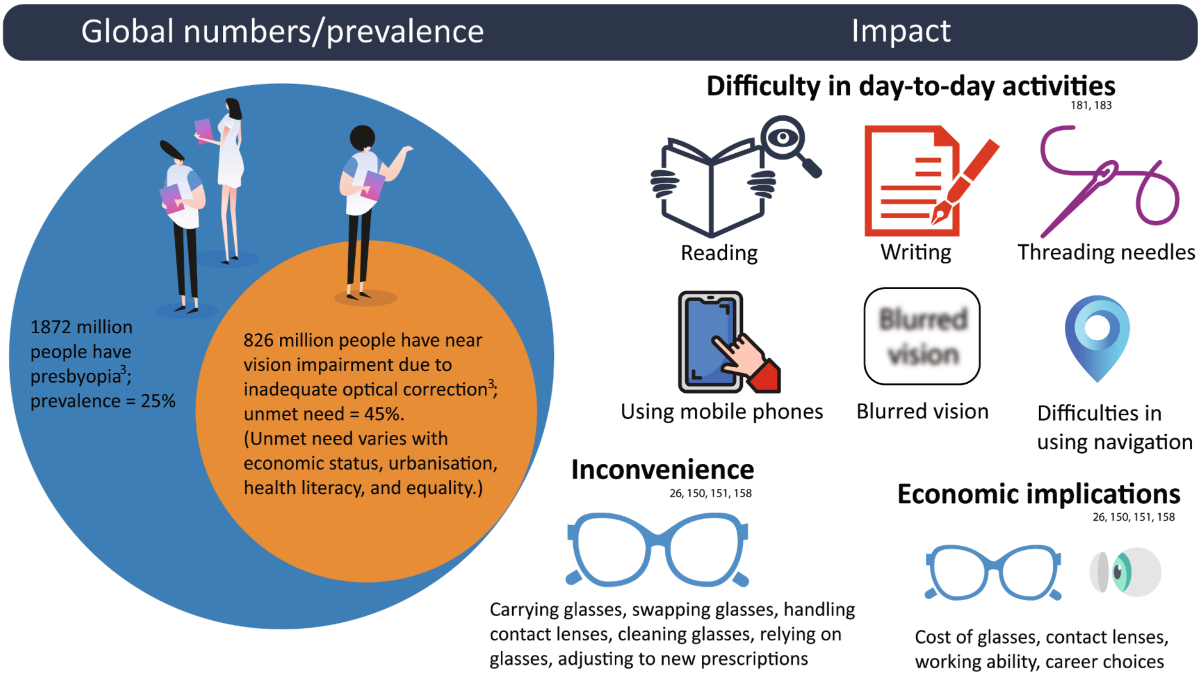

Fig. 4. Summary of the impact of uncorrected presbyopia on daily activities.

eREC terms at least. Some level of equity among community-members appears to assist average health care access, including eye health and refractive care.

2.6.6. Risk factors for early onset of presbyopia

2.6.6.1. Environmental factors. Geographic variations in the age of onset of presbyopia based on latitude have been reported. In a study involving 800 presbyopes in India, 35.8 % were considered early presbyopes, having entered presbyopia at or before the age of 38 [94]. This study concluded that high average ambient temperature or exposure to toxic factors may contribute to the early onset of presbyopia. Global analyses have suggested that proximity to the equator and living in lower altitude regions leads to higher ambient temperature and an earlier age of onset of presbyopia [109,110]. For example, it has been noted that the age of onset in the Bolivian high Andes is 48 to 50 years, but 39 years in the Bolivian plains [109]. It is unclear whether ambient temperature directly leads to earlier onset of presbyopia or whether there are other contributing factors.

Ultraviolet radiation has long been considered a contributing factor to the early onset of presbyopia [95]. However, there have been inconsistent reports on this aspect over the years and a more recent study recommended an improved measure of ocular exposure to ultraviolet radiation was needed [111]. Further studies are still required, but a contemporary paper found that blocking ultraviolet radiation with a contact lens was beneficial in maintaining accommodation ability and could be used to delay the onset of presbyopia [93].

2.6.6.2. Nutrition. Poor nutrition has been recognised as a risk factor for the early onset of presbyopia [94]. In a study of 800 presbyopes, most patients with premature presbyopia had a diet lacking in essential amino acids which have been shown to be incorporated into the proteins of the crystalline lens [94]. A more recent study has shown that antioxidant nutrients play a role in the prevention of age-related crystalline lens changes [112].

2.6.6.3. Near demands. Near demands have been shown to have both short- and long-term effects on accommodation amplitude [113–117]. It is difficult to differentiate whether the longer-term effects are directly due to the near work, or occur due to associated factors (for example, changes in refractive error status or ultraviolet radiation exposure). However, studies have shown that barriers such as service availability, cost, awareness, quality, confidence, and cultural safety are more significant than the near demands a person has in determining whether they seek and receive care for near vision problems [118].

The use of digital devices will potentially be the single largest influence on future near demands [119]. Market penetration of smart phones has spread dramatically over the past 15 years [120]. The use of smart phones may change the previously measured course of expected near demand. Various forms of virtual or augmented reality displays may also alter near demands.

2.6.6.4. Refractive error. Among other factors, such as focusing ability, depth of focus and habitual reading distance, it has been postulated that refractive error can be an element of early onset presbyopia [78]. It is possible that eyeball size, which is strongly related to its distant refractive error, may influence accommodative power and/or lens ageing. Aetiologically, hyperopia and presbyopia fall under different mechanisms (see BCLA CLEAR Presbyopia: Mechanism and optics)[74]; however, both can lead to near vision difficulties [121].

Theoretically accommodative demand at the corneal plane in spectacle-corrected hyperopia is greater than in myopia, given the same accommodative stimulus and degree of ametropia at the spectacle plane [122]. Thus, spectacle-corrected hyperopes effectively become presbyopes earlier than either people who are myopic or emmetropic. This has been demonstrated in a study of a Chinese population, where at baseline, the need for add power was not significantly different amongst subjects with different refractive conditions, whereas 6 years later, fully-corrected hyperopes showed an increased need for add power when compared with mild-myopes or emmetropic subjects [123]. It has also been directly shown in a study comparing accommodation with contact lens and spectacle lens use [124].

2.6.6.5. Accommodative dysfunction. When all else (age, location, sex, ethnicity, education, health literacy, nutrition, near demands, refractive error) is equal, there are still individual differences in accommodative ability. The distribution of accommodative amplitude is approximately normal [125], meaning that half of any community has less than average and technically prone to earlier presbyopia onset. The practical impact (percentage of people with measurably earlier presbyopia onset) of the normal distribution of accommodative skills appears to vary from around 2 % to 21 % [36].

Despite the reported earlier onset of presbyopia in women (see Section 2.6.4), they generally show relatively higher accommodative amplitude than men [78]. It was postulated that other sex differences, such as the need to perform for more near tasks for women, may account for this finding [78].

2.6.6.6. Medications. A number of medications can either trigger, or delay, the onset of presbyopia. Anticholinergic drugs (sich as atropine) block the effect of acetylcholine at muscarinic receptor sites in the iris sphincter and ciliary muscles [126]. Trihexyphenidyl hydrochloride (Artane) is an anti-muscarinic muscle relaxant used in the treatment of all forms of Parkinsonism [127]. Scopolamine is used in the treatment of motion sickness, available in oral, parenteral and transdermal patch forms [128]. All these medications, and any others that fall under this medication class, can lead to a reduction of accommodation and symptoms of presbyopia. Similar effects may accompany use of drugs that have anticholinergic side effects (Table 5).

Diuretics are commonly reported to lead to earlier onset of presbyopia due to the induced negative fluid balance and subsequent lenticular dehydration, leading to reduced accommodation ability [128]. Cardiac glycozides such as digoxin affect the activity of the autonomic nervous system and can lead to oculomotor and accommodative dysfunction [128].

Accommodation disorders, including accommodation infacility and insufficiency, can also be a side effect of a number of non-prescription or recreational drugs including alcohol [130], marijuana [122] and opioid analgesics [128]. The mechanism of action is oculomotor dysfunction and central nervous system depression [128].

Symptoms of accommodative insufficiency related to the use of the aforementioned prescription and non-prescription drugs are usually transient and related to drug dosage. The cycloplegic effects usually subside when the drug dose is lowered or discontinued [131].

There are also a number of medications that can delay the onset of presbyopia. Pilocarpine is a topical parasympathomimetic agent that stimulates the muscarinic receptor and can lead to ciliary muscle or accommodative spasm. It is predominantly used as a miotic in the treatment of glaucoma. A miotic pupil creates a pinhole effect and increased depth of focus [132]. A lower concentration of pilocarpine can be used in the treatment of presbyopia (see BCLA CLEAR Presbyopia: Management with scleral and pharmaceutical techniques report) [133].

Cholinesterase inhibitors block the usual breakdown of acetylcholine and can be found in reversible and irreversible forms [134]. The reversible form is mostly used in the treatment of neurodegenerative diseases such as Alzheimer's and Parkinson's disease, and myasthenia gravis [134,135]. The irreversible form can be found in pesticides and BioWare (nerve) agents [134,136,137]. Cholinergic toxicity, predominantly from the irreversible form of the drug, can lead to miosis [137] and delay the onset of presbyopia.

Opiates such as heroin, morphine, and codeine can constrict the pupil [138,122,131], so theoretically, if these substances are abused on a regular basis, they could delay the onset of symptomatic presbyopia.

2.6.6.7. Health conditions

2.6.6.7.1. Ocular conditions. Ocular disease and trauma that result in removal or damage to the lens, zonules or ciliary muscle can lead to early-onset presbyopia [139]. Some examples include blunt or penetrating trauma (including intraocular foreign body), ectopia lentis, ciliary body aplasia, aphakia following lens removal, Adie's syndrome and iridocyclitis [122].

2.6.6.7.2. Systemic conditions. Certain systemic diseases have been associated with an early onset of presbyopia. This includes conditions that effect neural innervation and accommodation ability, such as diabetes, multiple sclerosis, myasthenia gravis, Down's syndrome and the human immuno-deficiency virus (HIV) [139].

Several studies have shown a reduced amplitude of accommodation in patients with diabetes, particularly type 1, suggesting these patients may be more susceptible to developing early presbyopia [83,140,86,15].

Multiple sclerosis leads to demyelination of neural pathways and people with this condition have a lower amplitude of accommodation compared to age-matched healthy individuals [141].

Myasthenia gravis is a neuromuscular disorder that results in reduced signal transmission in skeletal muscles [142]. Patients with myasthenia gravis have only 10 to 30 % of the usual number of cholinergic receptors in their muscles [128]. There are many ocular manifestations of myasthenia gravis and a case analysis has shown that it can adversely impact accommodation [143] leading to signs of early presbyopia.

In children with Down's syndrome, accommodation is generally poor – a cross-sectional and longitudinal study found this to be true regardless of the refractive error present [144]. This study also found that the amount of accommodation elicited during testing did not reflect the maximum amplitude of accommodation, suggesting the accommodation system may lack accurate neuronal control.

A study of 64 participants found that amplitudes of accommodation were significantly smaller in HIV-positive participants compared to age-matched participants [145]. A 2017 study found similar results and suggested the reduction in accommodation amplitude may be due to direct neuronal infection by HIV-1, use of antiviral medication, or pathological changes of the lens and ciliary muscle [146 147].

Other systemic diseases that directly impact lens function may also be associated with an earlier onset of presbyopia. For example, a study in Portugal found that patients with familial amyloidosis had an earlier onset of presbyopia compared with a normal population (32 years versus 42 years) [37],. postulated to be due to amyloid material deposition on the anterior part of the lens capsule.

2.6.6.8. Sleep. A study of 2000 participants [100] found that healthy sleeping habits may delay the need for near correction. It was postulated that poor sleep quality, due to shift work and circadian rhythm disruption, may exacerbate presbyopia progression. However, further studies in this area are needed to confirm these findings.

2.7. Projected future prevalence of presbyopia and near eREC

Future prevalence projections of presbyopia depend, in part, on the definitions used. In general, populations are ageing due to both declining birth rates and increasing life expectancies. Ageing populations mean a greater proportion of the population have less ability to accommodate from far to near. However, as distant refractive error is trending towards myopia globally, this means the prevalence of functional presbyopia is likely to have peaked around 2020 is likely to be declining [3].

In terms of near eREC, variations around the world can be modelled by a combination of the human development index (community development improves near eREC), the gini coefficient (inequality worsens near eREC), and health expenditure (spending money on health improves near eREC) [3]. The human development index has been improving in most countries for several decades, sometimes dramatically. Health expenditure has also been increasing. If these covariate relationships hold over time, near eREC is likely to improve over time. However, inequality is a potential counter-balance; the gini coefficient of many countries has been increasing, signalling rising inequality, which is likely to act as a drag on near eREC improvements from the other factors, unless addressed.

One additional factor should be considered in future predictions of near eREC – the ophthalmic industry (professions, manufacturers, and service providers) have engaged in programs under the banner of Vision 2020 (the right to sight) for over two decades that have sought to improve access to eye care [148]. There are some measures suggesting that these programs have produced improvements in eye care outcomes exceeding those expected from community development in general [149].

3. The impact of presbyopia and near eREC on patient reported outcome measures (PROMs)

3.1. Methods of evaluating the quality-of-life impact of presbyopia

The impact of presbyopia or its correction method on an individual's life can be explored qualitatively through in-depth interviews or focus group discussions [150–153]. PROMs [26,154–157], also known as quality-of-life measures, are required to measure or quantify the impact on quality-of-life [158–160]. PROMs used in presbyopia may be presbyopia-specific or non-presbyopia-specific based on their content and targeted population (Table 6), (see BCLA CLEAR Presbyopia: Evaluation and diagnosis report) [2].

Presbyopia-specific PROMs are likely to be more sensitive to detecting quality-of-life issues related to presbyopia. However, their content may not be relevant to other eye conditions and non-presbyopia populations, hence do not allow a comparison of the impact of presbyopia with other conditions. For the existing presbyopia-specific PROMs, most of their content focuses on the activity limitation domain of quality-of-life (Fig. 3 and Table 7), although qualitative studies have highlighted that social and economic issues and non-visual ocular discomfort symptoms such as eyestrain may also have a substantial impact on quality-of-life in people with presbyopia [150,151].

3.2. Impact of presbyopia on quality-of-life

Most of the quantitative quality of life research in presbyopia is focused on evaluating the effectiveness of presbyopia treatments, particularly surgical procedures. There is limited evidence on the impact of uncorrected presbyopia on quality of life. The evidence from qualitative and limited quantitative research has demonstrated that presbyopia substantially affects people's quality of life across various dimensions such as activity limitation, inconvenience, emotional, social and economic status [150–152,186,156,153]. The increasing difficulty of performing near tasks has been reported to be associated with the magnitude of presbyopia [26].

PROMs have been used to compare the effectiveness of various presbyopia treatments. Using the National Eye Institute Refractive Quality of Life (NEI-RQL) instrument, it was concluded that multifocal contact lenses offer better outcomes than monovision contact lenses in patients with low astigmatic presbyopia [162], which was consistent with the findings from a study using the Activity of Daily Living (ADL) framework [161]. Likewise, a study using the NEI-RQL found that hyperopes with presbyopia had larger improvements in quality of life than their myope counterparts after multifocal intraocular lens implantation [163].

3.2.1. Impact of presbyopia on quality of vision

Quality of vision in presbyopia can be evaluated by using standard clinical tests such as near visual acuity, contrast sensitivity, aberrometry and PROMs (see CLEAR Presbyopia: Evaluation and diagnosis report) [2]. Quality of vision is an important aspect of quality of life which is a multidimensional construct including symptoms, activity limitation, mobility, and emotional, social and economic status [169,181,170].

Patients with presbyopia report difficulties with performing tasks at near distances. However, pre-presbyopic patients might experience visual symptoms when performing near tasks during prolonged periods of time, due to ill-sustained accommodation or decreased amplitude of accommodation) [183]. Hence, people aged 35 and older might present with asthenopia symptoms when working at near distances or using digital devices for long periods [183]. Digital eye strain is strongly associated with presbyopia and its associated factors, such as accommodative and vergence anomalies and closer working distance [187].

Different surgical and non-surgical visual approaches can be used in presbyopic patients to provide functional distant and near vision at the same time. The use of monofocal lenses for near vision (with other lenses for distant vision, when needed), together with monovision, bifocal and multifocal approaches are probably the most common ones [188]. These visual approaches can be achieved using spectacles, contact lenses, corneal laser techniques, intraocular lenses, or combining different techniques (see BCLA CLEAR Presbyopia: Management with reports) [189,43,44]. The results of the different approaches have their own advantages and limitations. For instance, with monovision, each eye is corrected for a different distant vision, so stereopsis is reduced due to the imposed anisometropia [178,184]. The reduction in stereopsis leads to difficulty in judging distances, which might limit the stability and security of patients when walking, driving or performing any other activity that implies movement or evaluating distances [184]. To try to overcome the limitation of full monovision, new approaches like micro-monovision (anisometropia induced $\leq$ 1.50 DS) [179,185] or implantation of corneal inlays [180] have shown promising results, although still with some limitations. Patients with bifocal and multifocal approaches achieve greater stereopsis than those with monovision approaches. However, bifocal approaches have the limitation of not providing visual correction for intermediate distances. Multifocal approaches also present their own visual problems, with halos and reduced contrast reported most frequently for these correction types [177]. In this regard, the vision quality of patients depends on the light intensity [182]. Currently, there are many different approaches that try to overcome the accommodation limitation, but none are able to restore the flexibility and efficacy of the natural accommodation system [5].

3.2.2. Impact on labour force participation

One of the most common reasons those with presbyopia seek and use optical correction is for work purposes [5,152,190]. Whilst the majority appreciate the benefits of both spectacle and contact lens correction in the workplace, some report difficulties and frustrations, especially during periods without appropriate visual correction [5,152,190]. Typical examples include not being able to read important documents, having to borrow other people's spectacles and/or with adjusting to new eyewear solutions [191,153] which could result in increased fatigue and absences from work [192]. Psychological related factors, for example the perception of looking unprofessional at work, have also been reported [153].

Associations between presbyopia and specific occupations can be found from small scale survey data usually in localised geographical areas. For dentists, operating working distance was found to be significantly greater in those over the age of 45 than in a group of undergraduate dental students [193]. A minimum standard of near visual acuity for practising dentists of 6/7.5 at 33 cm has been recommended [193]. In this study 93.5 %of those aged 45 years or older failed to achieve this minimum standard of near visual acuity [193]. Many older dentists work with less-than-optimal visual efficiency and comfort [194].

Several studies have found a high prevalence of presbyopia in teachers, with an unmet near need predominately in developing countries for presbyopia correction ranging from 29.6 to 70.4 % and a demonstrated improvement in near work efficiency with correction [195–197,14]. The main barriers to correction for presbyopia were a lack of awareness [89 198], self-rating of current vision as good, or cost-related factors [199].

As the majority of commercially available corrective spectacles used by workers do not provide effective eye protection against mechanical hazards in the workplace, those at risk should be given appropriate advice [200]. A small-scale study of welders found that those with or approaching presbyopia (older than 35 years) were 4.2 times more likely to have an ocular injury than those younger [201]. As a result of working for longer durations (10 years or more) they were more likely to have increased exposure to ultraviolet radiation, which is associated with ocular conditions such as pterygia, pingueculae, keratopathy, maculopathy and eye irritation, as well as presbyopia [201]. Ensuring those in need understand and are fully compliant with the appropriate options for the correction of presbyopia with personal-protective equipment is important, as is the need for regular eye care services. There is a lack of publications specifically around ocular safety for those with presbyopia.

A range of optical solutions are available for the correction of presbyopia in the workplace including lenses designed and marketed as occupational lenses (see BCLA CLEAR Presbyopia: Management with contact lenses and spectacles) [44]. Often due to commercial sensitivities, it is difficult to find peer-reviewed studies that substantiate some of the claims made by manufacturers in a work environment. Nevertheless, success is likely to be enhanced by selecting the design that best suits the individual's occupational and near vision needs with appropriate advice on visual ergonomics [202,203,5]. Progressive and bifocal contact lens designs on balance have been found to enhance functional vision and patient reported outcomes at work over other contact lens options available [204]. Research comparing the various surgical options and effectiveness of different intraocular lens designs generally reports positive PROMs [205]. However, data associated with the workplace are limited and equivocal, with benefits and limitations regardless of the option, be it with multifocal, extended depth of focus or monofocal intraocular lens designs. Notably, research and technology in this field is rapidly evolving [206–208].

3.2.3. Impact on work productivity and financial burden

The total global costs associated with correcting near vision due to uncorrected presbyopia have been estimated at $30.8 billion, with costs to multiple stakeholder groups including patients, society and employers [209]. A systematic literature review revealed that without optimal near correction a loss of productivity in working adults may occur [191]. The authors concluded that uncorrected presbyopia led to a 2-fold increased difficulty in near-vision-related tasks and a $>$ 8-fold increased difficulty in very demanding near-vision-related tasks, impacting the ability to perform necessary tasks [191].

Financial burdens to patients include time and cost for eye care services, purchasing eye wear, accessories like cleaning solutions, additional lighting, time off work and for some, loss of employment [210]. A recent publication concluded that low-cost interventions to eliminate visual impairment from uncorrected presbyopia would avert 1.2 billion presbyopia life-years and achieve $US1.05 trillion in productivity gains by 2050 [211].

The economic and social consequences could be significant in lower-income countries and impact employment prospects [19], where the majority (up to 94 %) may have uncorrected or under-corrected presbyopia [212] and few have spectacles for near work. These findings suggest that there is a significant unmet need for reading spectacles in these populations, with a particular need for quality and affordable eye wear solutions [213].

A study in India demonstrated an increased productivity of over 20 % by providing near spectacles for the correction of presbyopia for tea workers. They also found increased compliance with usage of the spectacles, to a level of 84.5 % by the end of the study [214]. Providing simple, cost-effective interventions for presbyopia is beneficial, and spectacles are among the most cost-effective healthcare interventions currently available for presbyopia [214]. In a study of a rural Filipino population, the majority of participants (84 %) reported that the near vision spectacles dispensed would greatly improve their ability to earn a living [215]. Reasons for discontinuation of spectacles included discomfort, damage, and loss or perceived acceptable vision without spectacles [213]. This highlights the importance of good education and awareness.

Data from a modelling study estimated that of all those in the working population age group (65 years or less), the potential productivity loss related to a lack of correction for presbyopia would be $US25.4 billion or 0.037 % of the global gross domestic product (GDP). The authors estimated that there were 826 million people with visual impairment resulting from uncorrected, or inadequately corrected, presbyopia and further estimated that if presbyopia was corrected to the level achieved in Europe, annual productivity losses could be reduced by $US10 billion to $US1.4 billion [212].

To estimate the impact that an impairment from a disease or condition has on work productivity over a longer time-frame than questionnaires would provide, a measurement known as productivity-adjusted life years (PALYs) can be calculated; this accounts for aspects including presenteeism (nonproductivity whilst at work), absenteeism (non-attendance to work) and changes to the workforce (ceasing employment) [216,217]. This can help provide useful economic insights to complement conceptually similar measurements such as disability-adjusted life-years (DALYs) and quality-adjusted life years (QALYs), by considering the impact on work productivity during the working life span until retirement. This has the potential to influence decision making regarding funding of health services and cost justification [218]. QALY measurements have been applied to various health diseases and ocular conditions including diabetes [219], hypertension [220] and migraine [221]. There are limited publications on PALYs when related to presbyopia. In a modelling study exploring the potential productivity loss due to a suboptimal correction of presbyopia in low- and middle-income countries found that the 240 million people with uncorrected and under-corrected presbyopia in 2019 equated to a potential $US54 billion loss of productivity; this added a further 155 million in QALYs, with a resultant total loss of $US315 billion [217]. This supports the need for investment in eye and healthcare strategies and services.

The burden of presbyopia on productivity and lifestyle without optimal correction is evident globally, and there are significant benefits from presbyopia treatment. Good education and service provision are important to increase awareness. Studies have also found a willingness to pay in excess of the price of spectacles and the preference to have various correction options depending on the needs of the day, showing the benefits are valued by those with presbyopia [222,190].

3.2.4. Impact on mental health

Presbyopia can trigger negative emotional responses including, but not limited to, feelings of embarrassment, anger, shame, denial, discomfort, insecurity, low sense of accomplishment and concern about presbyopia progression [23,191,210].

A study reviewing social media communications by those with presbyopia found that most posts discussing the impacts of presbyopia had an emotive nature (70 %), with content ranging from feelings of sadness through to happiness due to a positive treatment experience [152]. With regards to visual correction solutions, there were both positive and negative experiences shared [152]. A study using the "Time Trade Off" approach, which allows comparison of disease impact in terms of the number of life years individuals would give up to be disease free, showed that presbyopia affects quality of life to at least the same degree as distant vision impairment [223]. Comparison with other studies suggests this adverse impact is similar to that resulting from hypertension [224,191]. Patient reported questionnaires such as the Presbyopia Impact and Coping Questionnaire (PICQ) assist with the evaluation of coping mechanisms in those with presbyopia. Research implementing this approach found that patients tend to use similar strategies, with 15 compensatory coping behaviours identified to enhance visibility, the most common being making simple adaptions (changing image size or settings on electronic devices, repositioning physical objects further away) and utilising optical correction or squinting [156]. A total of 58 effects of presbyopia were reported, with emotional responses including feeling angry, the frustrations from forgetting spectacles and reliance on the support of others being the most common [156].

Medication taken for mental health conditions have been associated with ocular complications including decreased accommodative functionality [225], which could lead to signs/symptoms akin with presbyopia, or progression in those already with presbyopia. While the causes of mental health issues are likely to be multifactorial, risk factors include age, dry eye and visual impairment [226,227]. Anxiety and depression are reported upon diagnosis or induced by the management options for presbyopia in some individuals, more so than the introduction of other benign interventions in healthcare [228]. Data indicate that up to 8.6 % of older adults with vision loss meet the criteria for a depressive disorder, although this is not exclusive to presbyopia and more research to better understand links to mental health is desirable [229–231].

One observational study evaluated dual sensory loss and depression in 3782 older adults (65 years old and above), finding that vision loss was a risk factor for both onset and persistence of depression [232]. Conversely, studies have found that the use of optical devices to correct near vision have been associated with decreasing symptoms of depression [229]. Many older adults are at risk of loneliness often because of declining health and other age-related losses, which may impact the way they interact and engage with others [233]. Vision screening and optimal correction of visual problems such as presbyopia in those at risk may help increase social interaction [233].

3.2.5. Impact on social wellbeing

There is a general trend globally, that those with presbyopia report reduced quality of life than those without presbyopia, although data are limited [150–152,186,156,153]. There are also more difficulties with everyday living activities and an increased dependence on others for help and support in the case of uncorrected presbyopia [191,152,105]. Studies are often cross-sectional in design and questionnaires or interviews typically focus on one treatment type, mainly spectacles, although a few do review non-spectacle based options [234]. Pharmaceutical and surgical options remain niche portions of the presbyopia correction market. Recent reviews have considered potential future advancements in surgical options for presbyopia with the aim of improving quality of life and patient outcomes [105].

Studies utilising a multifaceted source approach have revealed further insights on social challenges for presbyopes including recognising faces, participating in activities involving reading or focus, trouble seeing in smoking environments and reluctance to attend events if they require driving at night [210].

3.2.6. Impact on physical health

Every year, an estimated 30–40 % of patients over the age of 65 will fall at least once [235]. Most often there is a multifactorial aetiology, with vision problems identified as a related risk factor [235,149,236]. Links between visual acuity, contrast sensitivity, stereopsis, and visual field impairment and falls have been identified in the literature [235,149,236]. As a vision-related management strategy, there is evidence of changing those using progressive, bifocal or monovision spectacles, to single vision lenses for use at critical distances for detecting obstacles in the environment, such as navigating stairs or outside the home can reduce the risk of falls [237–239,236,105]. The falls rate in patients switching to spectacle multifocals has been found to be double that of those patients who discontinued multifocal lens wear (30 % vs 15 %) [239]. In 2021, the direct medical costs related to falls associated with multifocal spectacles were estimated to be approximately $US11 billion annually in the United States of America [238,236]. One small-scale cross-sectional study comparing bilateral implantation of monofocal or multifocal intraocular lenses found better scores on mobility associated with fall risk with intraocular multifocal lenses [240]. Improving vision, through optical correction (including presbyopia management) and where appropriate cataract surgery, could form part of a multidisciplinary service delivery approach [241,242].

4. The impact of presbyopia and near eREC on health economics

4.1. Economic cost

In health economics, the “cost” of a condition describes the expense to an individual over a period (such as a year or a lifetime). An estimate of the cost of presbyopia would vary widely depending on the management choice of spectacles, contact lenses, eye drops or surgery, and various assumptions for each refractive correction. For example, for spectacles (the most common correction mode), the least expensive option would be ready-made magnifiers, which can be bought for as little as US$5 in most jurisdictions without any form of ophthalmic examination. In contrast, the other end of the cost spectrum would involve an ophthalmic examination including a patient-centred discussion of all presbyopia options (highly variable cost depending on location and public/private system, but around US$50–150 is not an unreasonable estimate in developed countries), leading to prescription, purchase and dispensing of progressive addition lenses (again, costs vary, but up to US $500 is common) in a spectacle frame (which have their own significant cost variations). Additionally, some people simply have one pair of presbyopia-correcting spectacles, while others will own multiple pairs at once. Also, there are no clear data describing how long the average person keeps their presbyopia-correcting spectacles for – the assumed replacement period will change the cost that is calculated [209]. Then there are additional costs that can be accounted for, including associated costs (such as transport to ophthalmic examinations and optical dispensers), productivity costs (such as work that did not get done due to time spent in ophthalmic examinations/optical dispensing), and indirect costs (quantification of broader productivity impacts of presbyopia measured via utility measures).

Similar issues arise in any estimate of cost of correcting presbyopia via contact lenses, eye drops, or surgery [209]. For example, should dual focus, extended depth of focus, multifocal, or monovision be used? How often should contact lenses be replaced? Does presbyopia surgery last forever, or only a fixed period before requiring supplemental spectacles, or repeat surgery?

The next issue is whose costs are being accounted for. There are genuine costs borne by individuals, families, communities, and governments. For example, in jurisdictions where individuals need to have an ophthalmic examination before they can obtain a prescription for presbyopic spectacles, someone needs to pay for the education of the ophthalmic professionals, the examination performed, and the work, materials, and expertise of the optical dispensers.

In summary, the lowest end of the presbyopia economic cost estimate could be as low as US$5 for a 3-year period. In contrast, the upper end could exceed US$4,000/year. The actual cost is likely to be somewhere in-between these extremes, and dependent on location, socioeconomic circumstance, sex, age, and other factors. Actual costs would need to be quantified by research in a wide enough diversity of communities, along with their relationship to measurable factors, to make a meaningful economic cost estimate.

4.2. Economic burden

In health economics, the “burden” of a condition quantifies all costs across all prevalent cases in a jurisdiction, over 1 year; it should include not just the cost of detection, diagnosis, and management of those who receive care, but also productivity loss for those who do not receive care, plus residual productivity loss for those who receive care that is less than a 100 % cure. For instance, if there were 1.8 billion people in the world with presbyopia, and the average cost of correcting them was US$5/3-year period, and everyone received this cheapest possible correction, and every one of them felt that the resultant near vision was a 100 %

cure, the annual global burden of presbyopia would be US$3 billion. At the other end of the cost spectrum (=US$4,000/year) with all other assumptions the same, the annual global burden of presbyopia would be US$7,200 billion. As identified in section 2, it is very unlikely that all people receive correction, let alone all receiving the same form of correction. As per Section 3, it is very unlikely that all people feel the resultant near vision is a 100 % cure for presbyopia. So, even if the cost research was complete, quantification of burden requires further work on near correction coverage rates, the impact of uncorrected presbyopia, and the residual impact of current presbyopia management options.

Potential lost “productivity” is a measure of the economic impact of a health condition. It can be measured “bottom-up”, where the impact of the condition is directly and specifically measured across representative participants. For example, the number of widgets assembled in a factory in a set time by people with uncorrected presbyopia can be compared to the number assembled by people with corrected presbyopia. Alternatively, it can be measured “top-down”, where an average per person impact is based on data that are not specific to the individuals being modelled. For example, utility values can be derived from expert panels [243], or a sample with somewhat comparable lived experience [223].

Following a top-down approach, the potential productivity loss from uncorrected presbyopia globally was estimated to be US$11 billion in 2011 [212]. This form of estimate is obviously specific to the time point as the number of prevalent cases changes with time, as do the spread of cases and dollar values. However, this estimate gives an example of the amount that would add to the US$3 billion – US$7,200 billion costs to correct known presbyopia cases.

4.3. Cost-effectiveness

Cost-effectiveness analyses seek to compare opportunity costs (how could society otherwise have used money and time spent on correcting presbyopia?), direct costs (detection, diagnosis, and management of presbyopia, including transport to care, and professional training), and indirect costs (potential productivity losses to presbyopia), with “effects” of treatment. Effects could include increased life expectancy (unlikely to be measurable from presbyopia care), decreased morbidity (that is other health impacts flowing from improved near vision, such as fewer mistakes reading systemic medication labels, or reduced risk of breaking a tooth on foreign bodies mixed in food), reduced disability (such as increased work force participation from improved near vision), and increased productivity (such as widget assembly in a factory from better near vision). Various units can be used in cost-effectiveness comparisons, including cost per QALY.

One study compared trifocal intraocular lenses versus monofocal intraocular lenses following bilateral cataract surgery in the United States of America [244]. The analysis was conducted from the patient perspective and found that patients were projected to spend an additional US$2,783 over their lifetimes. This was compared with a gain of 0.67 QUALYS. Assuming the individual willingness to pay to gain a QALY is the same as the societal willingness to pay to gain a QALY, this produces a life positive net monetary benefit. The level of benefit is most impacted by patients’ preference to wear/not wear spectacles, the out-of-pocket costs for the bilateral procedure, and post-operative spectacle dependence rates. The authors did not assess whether there is a societal positive net benefit that might generalise to countries with systems that rely more heavily on government-funded and government-provided medical care [244].

While cost-effectiveness is often used to aid decision-making by governments and insurance companies, it is worth pointing out that it should not be the only criterion – values, ethics, fairness and equity should also be considered.

4.4. Future impact and health economics

The number of people with presbyopia is expected to rise. As age expectancy and median age increase globally (and specifically in communities currently labelled as “developing”), digital transformation increases near acuity demands [149], and expectations on working life and retirement age increase, individuals will demand, and communities will need, improved access to better presbyopia correction. Given that near vision correction has not been delivered to all people who need this, either in the past or present, future increases in presbyopia needs, demands, and expectations will present a challenge to the eye care community, and communities more broadly.

It is beyond the scope of this review to design the presbyopia service delivery systems and correction options of the future. However, it is worth understanding that demand will be vast, and expectations are likely to be high. Presbyopia development will correlate with other degenerative conditions including cataract, glaucoma, and macular degeneration. Intelligently designed health systems will leverage management of symptomatic conditions such as presbyopia and cataract, to facilitate detection of (initially) asymptomatic conditions such as glaucoma and macular degeneration. The vast numbers will necessitate increased professionals to be trained, increased use of ophthalmic assistants, smart systems, increased use of artificial intelligence, or combinations of all of these approached.

5. Recommendations and future directions

Understanding the distribution of presbyopia, near eREC, and near vision impairment across and within communities can help identify those at risk, guide appropriate review periods and allow interventions to be initiated sooner. Current understanding makes it clear that presbyopia is a very common age-related condition that has significant impacts on both PROMs and economics.

However, there are complexities in defining presbyopia for epidemiological and impact studies. Standardisation of definitions will assist future synthesis, pattern analysis and sense-making between studies:

- The BCLA CLEAR Presbyopia: Evaluation and diagnosis report [2] should help with this, although it is important to recognise that individual, industry, and public health interests may each have valid interests that are served by different definitions.
- Reporting against a standard list of associated factors (such as sex-disaggregation, location that includes altitude, temperature and air pollutant information, systemic diseases, eye diseases, race/ethnicity, urbanisation) that influence presbyopia would improve future studies.
- There are marked differences in data availability from different regions. A gap analysis followed by studies targeted to fill the gaps would assist global coverage.
- Period (calendar year) and cohort (birth year of participants) will potentially influence both presbyopia epidemiology and impact, somewhat independently of age. So repeating studies in a specific location after a period of decade/s has potential value.

Developing strategies to inform the public, industry partners, governments, and eyecare practitioners of the impact of uncorrected presbyopia (Fig. 4) could improve access to services, and increase near eREC.

CRediT authorship contribution statement

Maria Markoulli: Conceptualization, Data curation, Writing – original draft, Writing – review & editing. **Timothy R Fricke:** Conceptualization, Data curation, Writing – original draft, Writing – review & editing. **Anitha Arvind:** Conceptualization, Data curation, Writing – original draft, Writing – review & editing. **Kevin D. Frick:** Conceptualization, Data curation, Writing – original draft, Writing – review & editing. **Kerryn M Hart:** Conceptualization, Data curation, Writing – original draft, Writing – review & editing. **Mahesh R Joshi:** Conceptualization, Data curation, Writing – original draft, Writing – review &

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Declaration of competing interest

Maria Markoulli, Timothy R. Fricke, Anitha Arvind, Kevin D. Frick, Kerryn M. Hart, Mahesh R. Joshi, Himal Kandel, Antonio Filipe Macedo, Dimitra Makrynioti, Neil Retallic, Nery Garcia-Porta and Gauri Shrestha have no declarations of competing interest. James S. Wolffsohn has received grant funding from Alcon and Rayner, is a paid consultant for Alcon, Atia Vision and Bausch + Lomb, and has stock ownership in Wolffsohn Research Ltd.

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