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FEATURE ARTICLE—PUBLIC ACCESS

Global Vision Impairment and Blindness Due to Uncorrected Refractive Error, 1990–2010

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ABSTRACT

The purpose of this systematic review was to estimate worldwide the number of people with moderate and severe visual impairment (MSVI; presenting visual acuity <6/18, ≥3/60) or blindness (presenting visual acuity <3/60) due to uncorrected refractive error (URE), to estimate trends in prevalence from 1990 to 2010, and to analyze regional differences. The review focuses on uncorrected refractive error which is now the most common cause of avoidable visual impairment globally.

The systematic review of 14,908 relevant manuscripts from 1990 to 2010 using Medline, Embase, and WHOLIS yielded 243 high-quality, population-based cross-sectional studies which informed a meta-analysis of trends by region. The results showed that in 2010, 6.8 million (95% confidence interval [CI]: 4.7–8.8 million) people were blind (7.9% increase from 1990) and 101.2 million (95% CI: 87.88–125.5 million) vision impaired due to URE (15% increase since 1990), while the global population increased by 30% (1990–2010). The all-age age-standardized prevalence of URE blindness decreased 33% from 0.2% (95% CI: 0.1–0.2%) in 1990 to 0.1% (95% CI: 0.1–0.1%) in 2010, whereas the prevalence of URE MSVI decreased 25% from 2.1% (95% CI: 1.6–2.4%) in 1990 to 1.5% (95% CI: 1.3–1.9%) in 2010. In 2010, URE contributed 20.9% (95% CI: 15.2–25.9%) of all blindness and 52.9% (95% CI: 47.2–57.3%) of all MSVI worldwide. The contribution of URE to all MSVI ranged from 44.2 to 48.1% in all regions except in South Asia which was at 65.4% (95% CI: 62–72%).

We conclude that in 2010, uncorrected refractive error continues as the leading cause of vision impairment and the second leading cause of blindness worldwide, affecting a total of 108 million people or 1 in 90 persons.
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Key Words: uncorrected refractive error, myopia, Global Burden of Disease Study, GBD 2010, blindness, vision impairment, vision loss

Refractive error (RE) is one of the most common ocular conditions, and uncorrected refractive error (URE) is a major public health challenge. Worldwide, URE is the leading cause of vision impairment (VI) and the second leading cause of blindness.[1,2] The impact of URE is profound, as not only do strong socioeconomic factors such as poverty and the inability to access treatment influence the correction of RE but URE can also contribute to the individuals' and their families' socioeconomic status.[3] Vision impairment due to URE have been observed to have extensive social and economic impact, for example,

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[a]A list of the Vision Loss Expert Group members appears at http://www.anglia.ac.uk/ruskin/en/home/microsites/veru/other_research_areas/global_burden_of_diseases.html.

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limiting educational and employment opportunities of economically active persons, healthy individuals, and communities. Smith et al. indicated that the global economy loses $269 billion annually as a result of lost productivity due to URE.[4]

Traditionally, the World Health Organization (WHO) used categories of VI that referred to best-corrected visual acuity in the better eye rather than "real world" or presenting visual acuity.[5] It was subsequently recognized that unless URE were included among the causes, VI at a global level was significantly underestimated,[6] thus limiting the relative importance of RE in causing blindness and VI. From the year 2000, a series of studies using a survey methodology, referred to as Refractive Error Study in Children (RESC), were performed in populations with different ethnic origins and cultural settings: a rural district in eastern Nepal[7]; a semi-rural county outside of Beijing, China[8]; an urban area of Santiago, Chile[9]; an urban and a semi-rural area of KwaZulu-Natal, South Africa[10]; a rural district near Hyderabad, India[11]; and an urban area of New Delhi, India.[12] These studies utilized data on presenting vision and confirmed the need for RE correction for children. In addition, Resnikoff et al.[1] in 2008 released data on the global prevalence of URE in 2004 providing VI estimates of 153 million people and blindness estimates of 8 million. The methods involved in this paper prevented a meaningful analysis of temporal change in the cause-specific contribution to blindness and visual impairment prevalence. However, it focused increased attention on URE as part of the eye health agenda and elevated the need for data for URE based on presenting vision.

We conducted, as part of the Global Burden of Disease, Risk Factors and Injuries Study 2010 (GBD), a systematic review of all available population-based prevalence studies performed worldwide between 1990 and 2010. The results informed a meta-analysis to estimate the number of people affected by blindness and VI globally, regionally and by cause, and yielded estimated temporal trends in prevalence from 1990 to 2010, and investigated regional differences worldwide. The present paper specifically details the contribution of URE to blindness and VI when compared to other major eye diseases as part of this meta-analysis.[2,13]

METHODS

The methodology utilized in this study has been described extensively in other Global Burden of Disease 2010 (GBD) papers.[2,13,14] A summary of this is presented below: We estimated 1990 to 2010 trends in VI causes and their uncertainties, by sex and severity of VI, for 21 GBD subregions.[14] A systematic review of medical literature from 1 January 1990 to 31 January 2012 identified indexed articles containing data on incidence, prevalence, and causes of blindness and VI. Only high-quality cross-sectional population-based representative studies were selected from which a database of age- and sex-specific data of prevalence of four distance and one near vision loss categories (presenting and best-corrected acuity) could be extracted.[14]

The studies that were included in the GBD Vision Loss database met the following requirement criteria[14]:

- The reported prevalence of blindness and/or VI must be measured from random sample cross-sectional surveys of representative populations of any age of a country or area of a country. Studies using hospital/clinic case series, blindness registries, and interview studies self-reported vision status were not included.
- The definitions of VI or blindness must be clearly stated, using thresholds of visual acuity, in the better eye
- Best-corrected and/or presenting visual acuity must be stated.
- The procedures used for measurement of visual acuity must be clearly stated.

Additional data sources were identified through personal communications with researchers, including enquiries about additional data from authors of published studies. These data were used only if information about the study population and measurement methods were available.

We identified 14,908 relevant manuscripts using Medline, Embase, and the WHO library information system. Most (13,574) articles were rejected during the abstract and title review process by two independent reviewers. A further 1130 articles were rejected by the consensus panel and finally 252 articles were used for our analysis (references can be found in the Web Appendix at www.anglia.ac.uk/verugbd). Search terms included concepts to describe "blindness," "VI," "population," "eye," "survey," and a list of conditions affecting the eye including URE. We supplemented the published study data with unpublished microdata sourced through personal communication with the principal investigators identified in the literature search. We estimated the contribution of six causes of VI: cataract, glaucoma, macular degeneration, diabetic retinopathy, trachoma, and URE. We also estimated the fraction of VI that had other causes. We made estimates for moderate and severe VI (MSVI defined as presenting visual acuity <6/18 but ≥3/60[13]) and blindness (blindness defined as presenting visual acuity <3/60). Our analysis was carried out in three steps: (1) data identification and access, described previously[13,14]; (2) estimation of cause fractions for each cause, by severity of VI, sex, age, and world region (for each cause, we used the subset of studies for which causal data were available); and (3) application of cause fractions to the prevalence of all-cause presenting VI, which were estimated as described previously.[2] For the statistical analysis, the DisMod-MR model from the GBD study was used to calculate the fraction of VI due to URE and the other causes. It has been described in detail previously.[2,13,15] DisMod-MR is a negative binomial regression model including the following elements: covariates that predict variation in the true proportion of VI from each disease (e.g., year); fixed effects that adjust for definitional differences (e.g., whether the causes of presenting vs. best-corrected VI were reported); a hierarchical model structure which fits random intercepts in individual countries derived from the data observed in the country, in its region, and in other regions based on the availability and consistency of country- and region-specific data; age-specific fixed effects allowing for a nonlinear age pattern; and a fixed effect for data on males. We used a specific set of parameters for each cause of VI.

The total prevalence of VI and its uncertainty were estimated using prevalence data of blindness and moderate and severe VI (MSVI) based on presenting visual acuity and best-corrected visual acuity.[13] This model implicitly estimated the difference

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between the prevalence of blindness (and of MSVI) based on presenting visual acuity and on best-corrected visual acuity prevalence, respectively. We interpreted this difference as the fraction of VI caused by URE.

For the presentation of the data, we age-standardized prevalence using the WHO reference population.[16] We also calculated the estimated numbers of people with VI and blindness due to refractive error, which reflected each region's population size and age structure.

RESULTS

A total of 243 high-quality, population-based studies remained after application of the above rigorous selection criteria and review by an expert panel.[2,13,14] URE was the second leading worldwide cause of blindness (after cataract) contributing in 1990 to 19.9% (95% confidence interval [CI]:14.9–24.9%) of all blindness and in 2010 to 20.9% (95% CI: 15.2–25.9%). In 1990 and 2010, the proportion of MSVI due to URE was 51.1% (95% CI: 45.6–56.0%) and 52.9% (95% CI: 47.2–57.3%), respectively, and as such remains the leading cause of all MSVI worldwide. In 2010, URE was the leading cause of MSVI in all regions with the proportion ranging between 43.2 and 48.1%, except in South Asia (Table 1). The proportion in South Asia where there is a relatively younger population was 65.4% (95% CI: 62.0–72.0%). South Asia also had a proportion of 36.0% of blindness due to URE compared to a low of 13.1% in North Africa/Middle East and Eastern Sub-Saharan Africa (Table 2).

TABLE 1.

Number of people moderately and severely visually impaired due to uncorrected refractive error, age-standardized prevalence in 1990 and 2010 by world region of all ages and those aged 50+ (95% confidence interval [CI]), percent of all moderate and severe visual impairment attributed to uncorrected refractive error (95% CI)

World region	Total population ('000s)	Total number of people affected ('000s) 95% CI			Age-standardized prevalence of all ages (95% CI)			Age-standardized prevalence of people aged 50+ (95% CI)			Percent of all moderate and severe visual impairment attributed to uncorrected refractive error (95% CI)
		Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper	
1990											
World	887027	87943	69870	103271	2.1%	1.6%	2.4%	6.9%	5.6%	8.0%	51.1 (45.6, 56.0)
Asia Pacific, high income	44400	767	481	2210	0.4%	0.2%	1.1%	1.5%	0.9%	4.2%	47.9 (38.4, 54.1)
Asia, Central	11000	660	392	978	1.4%	0.8%	2.0%	5.1%	3.1%	7.3%	45.1 (36.8, 51.6)
Asia, East	198000	14400	84	18400	1.6%	0.9%	2.0%	5.8%	3.5%	7.2%	44.8 (36.4, 51.7)
Asia, South	138000	38200	29000	49200	5.5%	4.3%	6.9%	18.5%	14.9%	22.4%	63.9 (60.0, 70.8)
Asia, Southeast	57800	6856	4645	9416	2.4%	1.7%	3.2%	8.4%	6.0%	10.9%	42.8 (34.2, 49.7)
Australasia	5014	187	94	366	0.7%	0.4%	1.5%	2.9%	1.4%	5.5%	46.5 (37.4, 53.1)
Caribbean	5514	496	271	625	1.8%	1.0%	2.3%	6.6%	3.7%	7.9%	43.4 (35.6, 50.4)
Europe, Central	32700	1732	957	2653	1.2%	0.6%	1.8%	4.4%	2.5%	6.6%	45.2 (36.1, 52.1)
Europe, Eastern	64600	3592	1798	5009	1.3%	0.6%	1.8%	4.8%	2.5%	6.6%	44.8 (36.6, 51.3)
Europe, Western	119000	3972	2412	6145	0.7%	0.4%	1.0%	2.6%	1.6%	4.0%	46.6 (37.9, 53.0)
Latin America, Andean	4685	524	317	683	2.3%	1.4%	2.9%	8.1%	5.3%	9.9%	43.4 (35.0, 50.8)
Latin America, Central	19400	1895	1232	2472	1.9%	1.3%	2.5%	7.0%	4.8%	8.8%	43.9 (35.6, 50.8)
Latin America, Southern	10100	698	421	1056	1.5%	0.9%	2.2%	5.5%	3.3%	8.1%	44.4 (35.6, 51.5)
Latin America, Tropical	20400	1885	1098	2545	1.9%	1.1%	2.5%	7.0%	4.3%	8.9%	44.2 (36.0, 50.9)
North Africa/Middle East	33600	4886	3348	6411	2.8%	2.0%	3.6%	9.2%	6.8%	11.4%	41.4 (33.1, 49.2)
North America, high income	71500	1422	1000	2350	0.4%	0.3%	0.6%	1.5%	1.0%	2.4%	47.8 (38.7, 54.3)
Oceania	548	82	44	111	2.8%	1.6%	3.6%	9.5%	5.9%	11.6%	43.5 (35.4, 50.6)
Sub-Saharan Africa, Central	5170	551	326	885	2.1%	1.3%	3.2%	7.6%	4.9%	10.8%	44.5 (35.5, 51.3)
Sub-Saharan Africa, East	19600	2265	1625	2882	2.2%	1.6%	2.8%	8.0%	5.9%	9.9%	44.0 (35.4, 50.6)
Sub-Saharan Africa, Southern	5496	383	264	546	1.5%	1.0%	2.0%	5.4%	3.9%	7.4%	45.9 (36.7, 52.6)
Sub-Saharan Africa, West	20500	2530	1727	3369	2.4%	1.7%	3.1%	8.6%	6.2%	10.6%	43.8 (35.0, 50.4)
2010											
World	1421546	101166	87765	125480	1.5%	1.3%	1.9%	5.3%	4.6%	6.5%	52.9 (47.2, 57.3)
Asia Pacific, high income	70500	939	579	2883	0.3%	0.2%	0.8%	1.0%	0.6%	3.0%	48.1 (38.6, 54.4)
Asia, Central	13800	547	346	1036	0.9%	0.5%	1.6%	3.3%	2.1%	5.8%	46.5 (37.2, 52.7)
Asia, East	341000	15400	10800	20300	1.0%	0.7%	1.4%	3.9%	2.8%	5.1%	46.1 (37.2, 52.8)
Asia, South	243000	46800	37800	62100	4.1%	3.3%	5.3%	14.6%	12.0%	18.7%	65.4 (62.0, 72.0)
Asia, Southeast	106000	8124	6127	12000	1.7%	1.3%	2.4%	6.1%	4.5%	8.7%	44.2 (35.2, 50.7)
Australasia	8358	215	101	444	0.5%	0.2%	1.1%	2.0%	0.9%	4.2%	47.1 (37.7, 53.5)
Caribbean	8605	547	328	728	1.3%	0.8%	1.8%	4.8%	2.9%	6.3%	44.6 (36.3, 51.2)
Europe, Central	41300	1535	914	2676	0.8%	0.5%	1.4%	3.0%	1.8%	5.2%	46.2 (36.7, 52.7)
Europe, Eastern	69400	2698	128	4336	0.8%	0.4%	1.4%	3.2%	1.5%	5.2%	46.1 (37.1, 52.6)
Europe, Western	154000	3545	2281	5845	0.4%	0.3%	0.7%	1.7%	1.1%	2.8%	47.3 (38.5, 53.7)
Latin America, Andean	8620	623	436	817	1.5%	1.1%	2.0%	5.6%	4.0%	7.1%	44.6 (36.0, 51.6)
Latin America, Central	38700	2294	1663	3140	1.3%	0.9%	1.7%	4.7%	3.5%	6.2%	45.2 (36.2, 51.6)
Latin America, Southern	15000	723	510	1199	1.0%	0.7%	1.7%	3.8%	2.7%	6.2%	45.4 (36.5, 52.0)
Latin America, Tropical	39700	2198	1441	3236	1.2%	0.8%	1.8%	4.5%	3.0%	6.5%	45.4 (36.7, 51.9)
North Africa/Middle East	64800	5898	4516	7988	1.9%	1.4%	2.5%	6.8%	5.2%	8.8%	43.2 (34.5, 50.1)
North America, high income	111000	1492	1006	2624	0.3%	0.2%	0.5%	1.1%	0.7%	1.9%	48.1 (38.9, 54.4)
Oceania	1034	110	63	147	2.2%	1.3%	2.8%	7.7%	4.9%	9.7%	44.5 (35.8, 51.3)
Sub-Saharan Africa, Central	8550	642	410	1093	1.5%	1.0%	2.5%	5.6%	3.7%	8.7%	45.9 (36.8, 52.4)
Sub-Saharan Africa, East	34500	3184	2420	4245	1.8%	1.4%	2.4%	6.7%	5.1%	8.5%	44.8 (36.0, 51.0)
Sub-Saharan Africa, Southern	9979	440	316	756	1.0%	0.7%	1.6%	3.8%	2.7%	6.0%	46.7 (37.4, 53.2)
Sub-Saharan Africa, West	33700	3224	2401	4317	1.9%	1.4%	2.5%	6.9%	5.3%	8.9%	44.8 (35.8, 51.2)

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TABLE 2.

Number of people blind due to uncorrected refractive error, age-standardized prevalence in 1990 and 2010 by world region of all ages and those aged 50+ (95% confidence interval [CI]), percent of all blindness attributed to uncorrected refractive error (95% CI)

World region	Total population ('000s)	Total number of people affected ('000s) 95% CI			Age-standardized prevalence of all ages (95% CI)			Age-standardized prevalence of people aged 50+ (95% CI)			Percent of all blindness attributed to uncorrected refractive error (95% CI)
		Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper	
1990											
World	886000	6339	4431	8109	0.2%	0.1%	0.2%	0.6%	0.4%	0.7%	19.9 (14.9, 24.9)
Asia Pacific, high income	44400	39	21	74	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	14.0 (8.4, 18.2)
Asia, Central	11000	28	16	41	0.1%	0.0%	0.1%	0.2%	0.1%	0.4%	13.7 (8.2, 17.6)
Asia, East	198000	809	462	1193	0.1%	0.1%	0.1%	0.4%	0.2%	0.6%	13.5 (8.0, 17.5)
Asia, South	138000	3396	1758	5165	0.6%	0.3%	0.9%	2.3%	1.2%	3.4%	35.4 (20.3, 45.9)
Asia, Southeast	57800	441	238	605	0.2%	0.1%	0.2%	0.7%	0.4%	1.0%	13.0 (7.8, 17.1)
Australasia	5014	49	3	12	0.0%	0.0%	0.0%	0.1%	0.0%	0.2%	14.0 (8.4, 18.0)
Caribbean	5514	27	15	41	0.1%	0.1%	0.2%	0.4%	0.2%	0.6%	13.3 (8.0, 17.4)
Europe, Central	32700	57	34	116	0.0%	0.0%	0.1%	0.2%	0.1%	0.3%	13.8 (8.2, 17.9)
Europe, Eastern	64600	131	59	223	0.0%	0.0%	0.1%	0.2%	0.1%	0.3%	13.8 (8.3, 17.7)
Europe, Western	119000	164	99	276	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	13.9 (8.3, 18.0)
Latin America, Andean	4685	26	12	37	0.1%	0.1%	0.2%	0.5%	0.2%	0.7%	13.3 (8.0, 17.4)
Latin America, Central	19400	112	63	166	0.1%	0.1%	0.2%	0.5%	0.3%	0.7%	13.2 (8.0, 17.2)
Latin America, Southern	10100	32	18	50	0.1%	0.0%	0.1%	0.3%	0.2%	0.4%	13.6 (8.1, 17.6)
Latin America, Tropical	20400	99	48	204	0.1%	0.1%	0.2%	0.5%	0.2%	0.9%	13.4 (8.0, 17.3)
North Africa/Middle East	33600	379	203	540	0.2%	0.1%	0.3%	1.0%	0.5%	1.4%	12.7 (7.6, 16.6)
North America, high income	71500	63	34	103	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	14.0 (8.4, 18.1)
Oceania	548	4	1	6	0.2%	0.1%	0.3%	0.6%	0.3%	1.0%	13.4 (8.0, 17.5)
Sub-Saharan Africa, Central	5170	37	19	71	0.2%	0.1%	0.3%	0.7%	0.4%	1.2%	13.3 (7.8, 17.2)
Sub-Saharan Africa, East	19600	211	114	291	0.2%	0.1%	0.3%	0.9%	0.5%	1.3%	12.9 (7.7, 17.1)
Sub-Saharan Africa, Southern	5496	41	20	57	0.2%	0.1%	0.2%	0.7%	0.3%	0.9%	13.2 (7.8, 17.3)
Sub-Saharan Africa, West	20500	241	138	327	0.3%	0.2%	0.4%	1.0%	0.6%	1.4%	12.9 (7.6, 17.0)
2010											
World	1420000	6759	4727	8826	0.1%	0.1%	0.1%	0.4%	0.3%	0.5%	20.9 (15.2, 25.9)
Asia Pacific, high income	70500	50	26	95	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	14.1 (8.4, 18.2)
Asia, Central	13800	19	11	29	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	13.9 (8.3, 18.0)
Asia, East	341000	721	412	1072	0.1%	0.0%	0.1%	0.2%	0.1%	0.3%	13.8 (8.2, 17.8)
Asia, South	243000	3814	2024	5236	0.4%	0.2%	0.5%	1.5%	0.8%	2.1%	36.0 (20.7, 46.6)
Asia, Southeast	106000	462	252	636	0.1%	0.1%	0.1%	0.4%	0.2%	0.6%	13.4 (8.0, 17.4)
Australasia	8358	5	3	14	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	14.1 (8.4, 18.1)
Caribbean	8605	27	14	39	0.1%	0.0%	0.1%	0.3%	0.1%	0.4%	13.5 (8.1, 17.8)
Europe, Central	41300	46	27	96	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	14.0 (8.3, 18.0)
Europe, Eastern	69400	82	37	144	0.0%	0.0%	0.0%	0.1%	0.0%	0.2%	14.0 (8.4, 18.0)
Europe, Western	154000	134	72	232	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	14.0 (8.4, 18.1)
Latin America, Andean	8620	27	14	39	0.1%	0.0%	0.1%	0.3%	0.1%	0.4%	13.6 (8.2, 17.7)
Latin America, Central	38700	123	71	189	0.1%	0.0%	0.1%	0.3%	0.2%	0.4%	13.5 (8.1, 17.5)
Latin America, Southern	15000	31	18	50	0.0%	0.0%	0.1%	0.2%	0.1%	0.3%	13.7 (8.2, 17.7)
Latin America, Tropical	39700	108	53	232	0.1%	0.0%	0.1%	0.2%	0.1%	0.5%	13.6 (8.1, 17.5)
North Africa/Middle East	64800	409	231	582	0.1%	0.1%	0.2%	0.6%	0.3%	0.8%	13.1 (7.8, 17.1)
North America, high income	111000	67	35	113	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	14.1 (8.4, 18.2)
Oceania	1034	4	2	7	0.1%	0.1%	0.2%	0.4%	0.2%	0.7%	13.6 (8.1, 17.7)
Sub-Saharan Africa, Central	8550	38	20	77	0.1%	0.1%	0.2%	0.4%	0.2%	0.8%	13.6 (8.0, 17.5)
Sub-Saharan Africa, East	34500	273	148	381	0.2%	0.1%	0.2%	0.7%	0.4%	1.0%	13.1 (7.8, 17.2)
Sub-Saharan Africa, Southern	9979	40	19	57	0.1%	0.0%	0.1%	0.4%	0.2%	0.6%	13.5 (8.0, 17.7)
Sub-Saharan Africa, West	33700	277	168	371	0.2%	0.1%	0.2%	0.7%	0.4%	1.0%	13.2 (7.8, 17.3)

The prevalence of blindness in all ages due to uncorrected refractive error decreased from 0.2% (0.2%; 95% CI: 0.1–0.2%) in 1990 to 0.1% (0.1%; 95% CI: 0.1–0.1%) in 2010, a 33% reduction. The prevalence of MSVI due to uncorrected refractive error decreased from 2.1% (2.1%; 95% CI: 1.6–2.4%) in 1990 to 1.5% (1.5%; 95% CI: 1.3–1.9%) in 2010, a 25% reduction.

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In 2010, out of 32.4 million blind and 191 million moderate and severely vision impaired worldwide,[13] an estimated 6.8 million (95% CI: 4.7–8.8 million) people were blind (Table 2) and 101.2 million (95% CI:87.8–125.5 million) moderate and severely vision impaired (Table 1) due to URE, whereas in 1990, 6.3 million (95% CI: 4.4–8.1 million) were blind and 87.9 million (95% CI: 69.9–103.3 million) were moderate and severely vision impaired out of a total of 31.8 million blind and 172 million with moderate and severe VI. This represents an increase in the estimated number of people blind (7.9%) and visually impaired (15.1%), whereas the global population increased by 30% from 1990 to 2010 (Figs. 1 and 2).

Globally, the age-standardized prevalence of blindness and MSVI combined among people aged 50 years and older declined substantially from 1990 to 2010 from 7.5% (95% CI: 6.1–8.5%) to 5.7% (95% CI: 5.0–6.9%), respectively. URE contributed to the largest decline in this prevalence (20% for blindness and 45% for MSVI). Regionally, the percentage reduction in age-standardized prevalence of URE as a cause for adult blindness and MSVI combined was most marked in Tropical Latin America (35.1%), Central Asia (35.8%), and high-income Asia Pacific (33.3%), and least marked in eastern Sub-Saharan Africa (16.8%), Oceania (19.8%), and western Sub-Saharan Africa (19.8%) (Figs. 1 and 2).

Age-standardized prevalence of refractive error–related blindness worldwide was 0.4% (95% CI: 0.3–0.5%) in adults aged 50+ years in 2010 and a reduction of 33% to 0.6% (95% CI: 0.4–0.7%) for 1990 (Table 2). The age-standardized prevalence of refractive error–related MSVI worldwide decreased to 5.3% (95% CI: 4.6–6.5%) in 2010 from 6.9% (95% CI: 5.6–8.0%) in 1990 (Table 1).

In 2010, the global age-standardized prevalence of refractive error blindness was the same in men and women (0.1% [95% CI: 0.1–0.2%]), whereas the age-standardized prevalence of VI was greater in women (1.6% [95% CI: 1.4–2.0%]), than in men (1.4% [95% CI: 1.2–1.8%]). This disparity in VI due to refractive error between men and women existed in all regions of the world.

DISCUSSION

We found that in 2010, 6.8 million people were blind and 101.2 million people were vision impaired due to URE worldwide, a total of 108 million blind or MSVI. Further, URE is the leading cause of moderate and severe vision impairment.

Our results vary from some of the previous estimates by Resnikoff et al.[1] and Dandona and Dandona.[17] In 2008, Resnikoff et al.[1] reported that 153 (123–184) million had VI (blindness and MSVI) of which 8 million were blind, whereas Dandona and Dandona[17] using population estimates for 2004 and 2002 stated that 98 (82–117) million had VI (blind and MSVI). Dandona and Dandona[17] only considered nine studies for their analysis and utilized only published data and excluded data from studies on children or those older than 60 years. Our estimates fall within the range suggested by Dandona and Dandona[17] except their estimates are for 2002. We found a 7.9% increase in the number of individuals blind due to URE and a 15% increase for those with MSVI from 1990 to 2010 compared to the Resnikoff et al. study. The inconsistency in comparing these results may be explained by the variation in methodology and the greater degree of granularity in our analysis by presenting data in 5-year age groups and by sex, by calculating time-series estimates for the period 1990 to 2010, and by disaggregating the estimates for

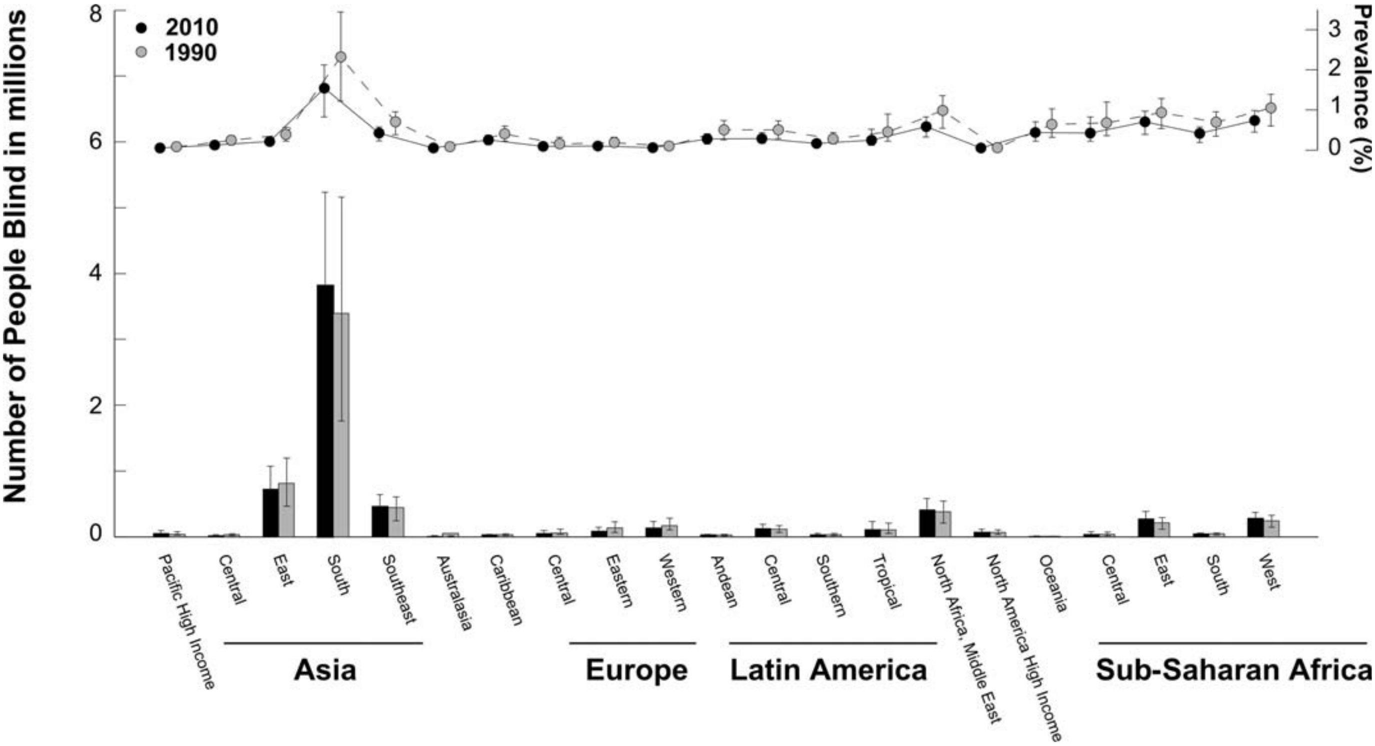

FIGURE 1.
Number of people blind (in millions) due to uncorrected refractive error and age-standardized prevalence of those aged 50+, by world region in 1990 and 2010.

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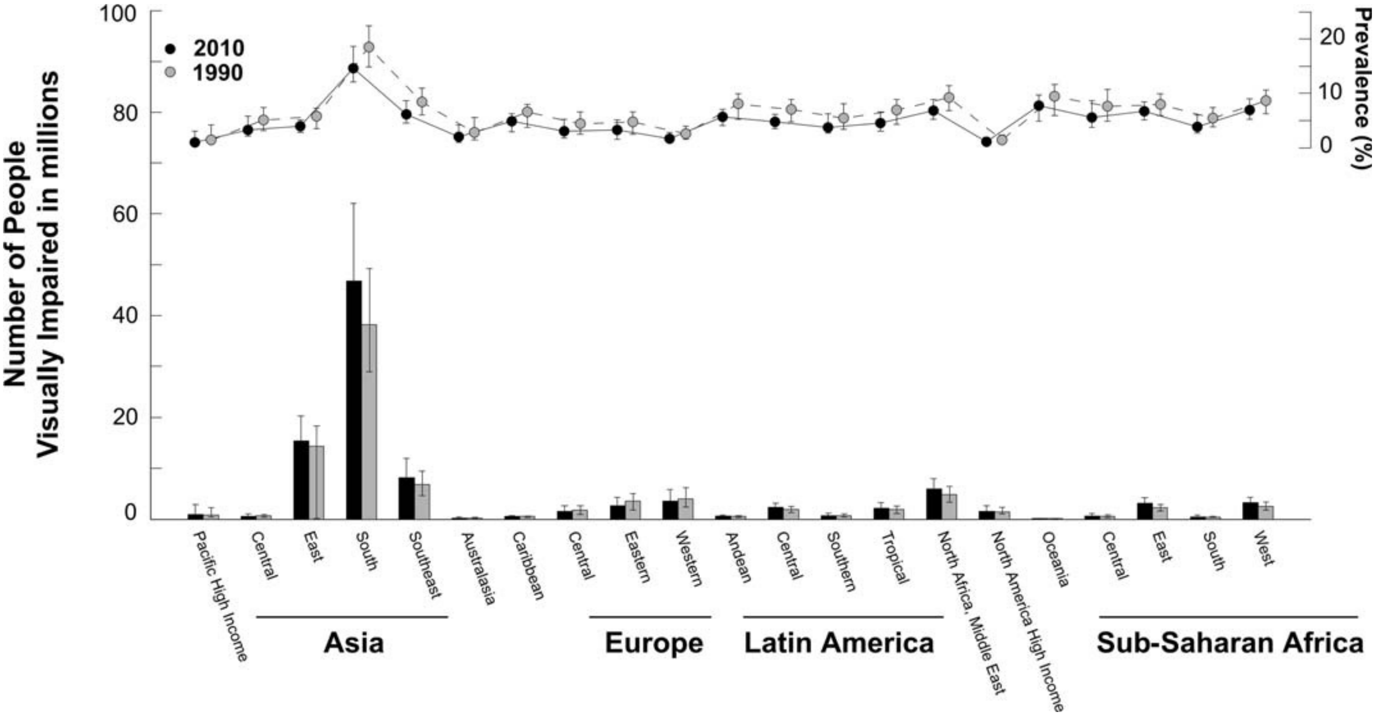

FIGURE 2.

Number of people moderately and severely visually impaired (in millions) due to uncorrected refractive error and age-standardized prevalence in of those aged 50+ by world regions in 1990 and 2010.

190 countries in 21 regions. Thus, we believe our estimates of prevalence of VI have increased detail and show temporal changes with more accuracy (Fig. 3).

It is encouraging to note that the prevalence of blindness and MSVI due to uncorrected refractive error decreased by 33 and 25%, respectively, from 1990 to 2010. The total number of persons blind or vision impaired due to URE grew relatively less (7.9 and 15%, respectively) compared to the population growth of 30%. This could be a consequence of increased focus on URE service delivery programs and human resource development by VISION 2020,

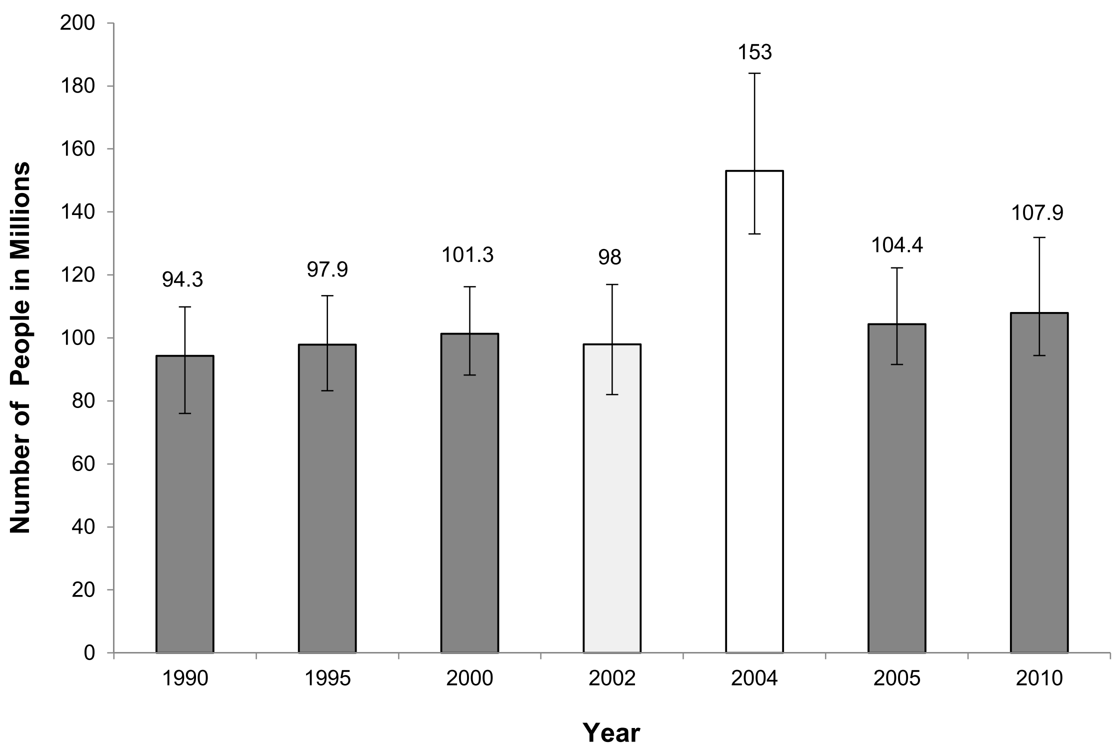

FIGURE 3.

Change in numbers of people (in millions) blind and visually impaired by uncorrected refractive error by 5-year increment. The gray column in 2002 represents the results found by Dandona et al.[18] in 2002, and the white column in 2004 represents the Resnikoff et al.[1] results in 2004.

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national programs, non-government and development organizations, and professional associations. The change from best-corrected to presenting visual acuity in determining the magnitude of URE possibly contributed to this by elevating its relative importance to blindness and VI and thus motivating increased investment in refractive error programs.

Unlike the previous reviews of URE by Dandona and Dandona[17] and Resnikoff et al.,[1] our analysis provided data on sex variations with age-standardized prevalence of VI greater in women than in men in all regions of the world. A meta-analysis of population-based surveys on blindness prevalence in Asia, Africa, and the developed countries in 2000 indicated that women bear approximately two-thirds of the burden of blindness in the world.[18] The excess blindness in women occurred in all the regions studied, but the factors behind the disparity vary by geopolitical regions.[18] Mganga et al.[19] postulated that in developed countries, the overall excess blindness in women was due to the fact that there are more numbers of elderly women than elderly men. In less-developed countries, the greater longevity of women contributes, but access to services is also a major factor, highlighting the need to address specific strategies to reach women, particularly in societies where barriers to women accessing eye care exist.[19]

South Asia had the highest prevalence of MSVI of all regions. However, it should be considered that the basic studies were conducted in different time periods and at different locations, and there could have been a regional disparity in the estimates. The large countries such as India and others could present large regional differences in prevalence and causes of VI even at a given point in time.

The design of our study had potential limitations. As also pointed out in our previous reports on the global prevalence of vision loss,[3,14] a major limitation was that many country-years remained without data or only had sub-national data. Only a few national studies reporting VI for all ages and all causes were available. The increased number and broader distribution of recent data sources underscores an increase in population-based studies conducted in the 2000s compared to the previous decades; however, there remains a dearth of such information from certain world regions such as Central Africa and Central and Eastern Europe, the Caribbean, and Latin America.[14] Some data sources did not report prevalence by age. To use these data, we imputed age-specific cause fractions, assuming that the age pattern of vision impaired in the study matched the modeled age pattern of vision impaired in the country where the study was conducted.[3] Finally, some studies had a relatively small sample size; therefore, the confidence intervals of the cause-specific prevalence estimate were relatively large. Our methods, however, took into account sample size, so that studies with small sample sizes influenced the estimates less than studies with large sample sizes. The lack of data for near VI due to presbyopia during the period of our study remains a major limitation of our study.

CONCLUSIONS

In 2010, 6.8 million people were blind and 101.2 million vision impaired due to URE with increasing numbers from 1990 (6.3 million were blind and 88.0 million were vision impaired). In 2010, uncorrected refractive error continues as the leading cause of vision impairment and the second leading cause of blindness worldwide, affecting a total of 108 million people or 1 in 90 persons. The most frequent cause for MSVI and the second most common cause for blindness was URE. Our data again emphasizes that globally one of the most simple, effective, and cost effective ways to improve the burden of vision loss would be to provide access to affordable adequate spectacles to correct refractive errors with the appropriate human resources.

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