Inequality in cataract blindness and services: moving beyond unidimensional analyses of social position

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Abstract

Objective

Inequalities in cataract blindness are well known, but data are rarely disaggregated to explore the combined effects of a range of axes describing social disadvantage. We examined inequalities in cataract blindness and services at the intersection of three social axes.

Methods

Three dichotomous social variables (sex [male/female]; place of residence [urban/rural]; literacy [literate/illiterate]) from cross-sectional national blindness surveys in Pakistan (2001-4; n=16,507) and Nigeria (2005-7; n=13,591), were used to construct eight subgroups, with disadvantaged subgroups selected *a priori* (i.e. women, rural dwellers, illiterate). In each dataset, the social distribution of cataract blindness, cataract surgical coverage (CSC), and effective cataract surgical coverage (eCSC) were examined. Inequalities were assessed comparing the best- and worst-off subgroups using rate differences and rate ratios (RR). Logistic regression was used to assess cumulative effects of multiple disadvantage.

Results

Disadvantaged subgroups experienced higher prevalence of cataract blindness, lower CSC and lower eCSC in both countries. A social gradient was present for CSC and eCSC, with coverage increasing as social position improved. Relative inequality in eCSC was approximately twice as high as CSC (Pakistan: eCSC RR 2.7 vs CSC RR 1.3; Nigeria: eCSC RR 8.7 vs CSC RR 4.1). Cumulative disadvantage was observed for all outcomes, deteriorating further with each additional axis along which disadvantage was experienced.

Conclusion

Each outcome tended to be worse with the addition of each layer of social disadvantage. Illiterate, rural women fared worst in both settings. Moving beyond unidimensional analyses of social position identified subgroups in most need; this permits a more nuanced response to addressing the inequitable distribution of cataract blindness.

INTRODUCTION

Cataract is the leading cause of blindness globally.[1] Reducing cataract blindness is a priority in the *Universal Eye Health: a Global Action Plan 2014-2019* [2] (hereafter called the UEH Action Plan) endorsed at the 66th World Health Assembly in 2013. The UEH Action Plan aligns with the broader Universal Health Coverage (UHC) initiative and recognises the importance of promoting equity to achieve universal eye health (UEH). Assessing progress towards health equity necessitates monitoring inequality (i.e. the measurable differences between subgroups).[3]

Cataract blindness and services are unequally distributed across countries and regions, with higher rates of cataract blindness and worse cataract service indicators in poorer and less developed settings.[1,4] Within countries, women generally [5,6]—but not always [7]—are more likely to be cataract blind than men, with lower access to and use of cataract surgical services. Data to monitor inequalities beyond gender are not routinely collected and reported.

A small number of surveys have analysed cataract outcomes for associations with social variables such as place of residence (urban/rural) and education level and/or literacy, usually as independent risk factors in multivariable logistic regression models.[8-10] However, because individuals are not unidimensional (i.e. male *or* female, and separately, literate *or* illiterate, urban *or* rural), the multivariable approach typically fails to capture the experience of specific subgroups. Little insight is typically available for the groups 'in the middle' such as illiterate men or literate women, and removes the opportunity to understand how social factors interact with one another to increase vulnerability in the most disadvantaged.[11]

This study aimed to assess inequality in cataract blindness and cataract services at the intersection of three social variables using data from national surveys in Pakistan and Nigeria.

METHODS

Data sources

Data from nationwide representative surveys in Pakistan and Nigeria were selected for analysis as they are among the largest blindness surveys undertaken, collected data on a wide range of social variables, and used comparable methods.[12,13] Participant characteristics and previously reported cataract outcomes from these surveys are summarised in Table 1.

Ethical approval for the surveys was granted prior to original collection by the relevant entities in each country. For the analyses presented here, approval was obtained from the London School of Hygiene & Tropical Medicine Ethics Committee (Reference 6248).

Table 1: Summary of datasets and cataract results from National Blindness and Visual Impairment Surveys in Pakistan and Nigeria used in this analysis

	Pakistan National Blindness and Visual Impairment Survey[a]		Nigeria National Blindness and Visual Impairment Survey[b]	
Survey details				
Years of survey	2001–2004		2005–2007	
Sample size	16,507		13,591	
Age (years)	≥30		≥40	
Participation rate (%)	95·3		89·9	
Cataract results				
Crude prevalence of cataract blindness (presenting vision <20/400 better eye)(%; 95%CI)	1·75 (1·55–1·95)		1·80 (1·57–2·05)	
Proportion of all blindness due to cataract (%)	51·5		43·0	
Number with ‘operable cataract’ (<20/200 in the better eye)	904,000 (736,000–1,107,000) [c]		399,041 [d]	
Age and sex adjusted multivariable logistic regression[a,b]				
Associated with higher cataract blindness and lower CSC	**Cataract blindness**	**CSC**	**Cataract blindness**	**CSC**
Female sex	Yes	Yes	Yes	Yes
Illiteracy	Yes	Yes	Yes	Yes
Rural dwelling	Yes	Yes	No	Yes

a Results reported in Dineen 2007 [14], Jadoon 2007 [15].
b Results reported in Abdull 2009 [16], Abubakar 2012 [8].
c Age- and sex-standardised using Pakistan’s population in 1998.
d Age- and sex-standardised using Nigeria’s population in 2008.

Outcome variables

The three outcome variables examined were cataract blindness, cataract surgical coverage (CSC), and effective cataract surgical coverage (eCSC).

Cataract blindness was defined as presenting visual acuity (VA) of worse than 3/60 in the better eye where the principal cause was cataract.[12,13]

Cataract surgical coverage measures the number of people in a defined population with operated cataract as a proportion of those having operable plus operated cataract. In this study ‘operable cataract’ was defined as cataract causing blindness (i.e. presenting VA worse than 3/60). CSC was calculated using the formula $[(x + y)/(x + y + z)] *100$ where x is individuals with unilateral pseudo/aphakia (i.e. operated cataract) and operable cataract in the other eye; y is individuals with bilateral pseudo/aphakia; and z is individuals with bilateral operable cataract.[8,15]

Effective cataract surgical coverage (eCSC) measures the number of people in a defined population with operated cataract and a good outcome (i.e. presenting VA 6/18 or better) as a proportion of those having operable plus operated cataract. eCSC was calculated using the formula $[(a + b)/(x + y + z)] *100$ where a represents individuals with unilateral pseudo/aphakia achieving presenting VA of 6/18 or better in the operated eye and operable cataract in the other eye; b describes individuals with bilateral pseudo/aphakia achieving presenting VA of 6/18 or better in at least one eye; and x, y and z are the same as for CSC.

Social variables

The social variables used, hereafter described as ‘axes’, were 1) sex (male or female), 2) literacy (literate [read and write easily] or illiterate [read or write with difficulty or not at all]) and 3) place of residence (urban or rural [the latter defined as a settlement with a population of <20,000]). Eight subgroups were generated in each dataset by combining these axes (Box 1). The subgroups selected *a priori* as more advantaged on each of the axes were males, literate individuals, and urban dwellers.

Box 1: Subgroups created by disaggregating women and men by literacy status and place of residence

1 axis **Sex**	**2 axes** **Sex + Literacy Status**	**3 axes** **Sex + Literacy Status + Place of residence**
Female**	Illiterate**	Rural**
		Urban
	Literate	Rural
		Urban
Male*	Illiterate	Rural
		Urban
	Literate*	Rural
		Urban*

*The subgroup selected *a priori* as more advantaged on each of the axes were males, literate individuals, and urban dwellers. When two or more social axes were combined, the most advantaged subgroup was assumed that which contained the more advantaged across each axis separately: 2 axes=Literate male, 3 axes=Urban literate male.

**Correspondingly, the assumed worst-off subgroup was: 1 axis=Female, 2 axes=Illiterate female, 3 axes=Rural illiterate female

Analysis methods

Analyses were conducted using STATA 12.0 (StataCorp, College Station, TX, USA).

The social distribution of cataract indicators were examined by calculating cataract blindness prevalence, CSC, eCSC, and their 95% confidence intervals (95% CI) for each subgroup listed in Box 1, and constructing graphs for each outcome.

The World Health Organization recommends rate differences (RD) and rate ratios (RR) as simple measures to monitor health inequality.[17] We selected the most advantaged subgroup as the reference group for calculations (i.e. literate, urban males, Box 1). RDs (rate in best-off subgroup minus rate in worst-off subgroup) and RRs (rate in best-off subgroup / rate in worst-off subgroup) were calculated for CSC and eCSC. A positive value for RD and RR>1 indicates worse health in the disadvantaged. The more RD diverges from zero and RR diverges from one, the greater the inequality. Conversely, a negative value for RD and RR<1 indicates worse health in the subgroups that were assumed to be advantaged.

To examine the cumulative effect of multiple disadvantage, literacy status and place of residence were added to sex in turn, and the increased odds of higher cataract blindness, and lower CSC and eCSC in the worst-off compared to best-off subgroup was calculated using multiple logistic regression. Nine models were constructed in each country—one for each of the three outcomes (cataract blindness, CSC, eCSC) for three axis combinations. The assumed best-off subgroup (shown by * in Box 1) was used as the reference group, and age was forced into the model. For each outcome, age-adjusted odds ratios and 95% CI were plotted comparing 1) men and women; 2) literate men and illiterate women; and 3) urban, literate men and rural, illiterate women. Goodness of fit was assessed using the chi-squared test.

RESULTS

Social distribution of cataract indicators

Cataract blindness

The social distribution of cataract blindness was similar in both countries, with illiterate women and men having a higher prevalence than their literate counterparts. Within literacy subgroups, rural dwellers had a higher prevalence than urban dwellers (Figure 1). Literate urban dwellers had the lowest prevalence in both countries: in Pakistan literate, urban men (0.1%, 95%CI 0–0.5) and in Nigeria literate, urban women (0.4%, 95%CI 0–0.9). Conversely, illiterate, rural men in Pakistan (2.7%, 95%CI 2.2–3.3) and illiterate, rural women in Nigeria (2.9%, 95%CI 2.4–3.3) had the highest prevalence of cataract blindness.

In Pakistan, despite two subgroups of men having the highest prevalence of cataract blindness (2.7% [95%CI 2.2–3.3] in illiterate, rural men and 2.4% [95%CI 1.5–3.5] in illiterate, urban men compared to 2.2% in both of the corresponding subgroups of women [95%CI 1.8–2.6 and 1.6–2.9 respectively]), the overall prevalence was lower in men (1.6%, 95%CI 1.3–1.9) compared to women (1.9%, 95%CI 1.7–2.2). This is due to the higher level of social disadvantage experienced by women—the two most disadvantaged subgroups of men comprised 25% of the sample, whereas the corresponding subgroups of women comprised 45% of the sample (Figure 1). In Nigeria, the proportion of women in the two most disadvantaged subgroups (39%) was more than twice that of men (17%), leading to an even greater difference in overall prevalence between women (2.2%, 95%CI 1.9–2.6) and men (1.3%, 95%CI 1.0–1.6) (Figure 1).

Cataract surgical coverage and effective cataract surgical coverage

A social gradient was observed among women and men for CSC and eCSC, with coverage increasing as social position improved, being lowest for illiterate rural dwellers and highest for literate urban dwellers (Figure 2). The slope of the gradient was steeper for men than women in Pakistan, whereas in Nigeria the opposite was observed, with greater differences among women than men. In Pakistan, inequality in eCSC was approximately twice as high as inequality in CSC in both absolute and relative terms—absolute inequality (RD) was 21.6% for CSC and 45.9% for eCSC, and relative inequality (RR) was 1.3 (95%CI 0.9–1.8) for CSC and 2.7 (95%CI 1.8–4.0) for eCSC. In Nigeria relative inequality also around twice as high in eCSC (RR=8.7) compared to CSC (RR=4.1). In absolute terms inequality in eCSC (RD=44.2%) was lower than for CSC (RD=64.6%), partly due to much lower rates of eCSC.

Cumulative disadvantage

Cumulative disadvantage was evident for all outcomes, with increasing odds of higher cataract blindness prevalence, lower CSC and lower eCSC with the addition of each axis of disadvantage (Figure 3). The findings were similar in both countries.

DISCUSSION

The UEH Action Plan states that "*All people should have equitable access to health care and opportunities to achieve or recover the highest attainable standard of health, regardless of age, gender or social position*",[2] closely aligning with UHC aims.[18] Our results show that at the time these surveys were completed there was much to be done to achieve UEH in Pakistan and Nigeria. Despite differences in sociocultural and health system contexts, both countries had large numbers of people blind from cataract (Table 1), with a disproportionate number being in disadvantaged social groups (Figure 1). The most disadvantaged groups also had lower CSC (Figure 2), most likely due to barriers to accessing services not experienced by their more advantaged counterparts. Amongst those who accessed surgery, the disadvantaged were less likely to have good visual outcomes than the more advantaged (eCSC, Figure 2). The larger inequality observed in eCSC compared to CSC highlights the compounding disadvantages of poorer access and worse quality for those already socially disadvantaged. This phenomenon was described decades ago as the inverse care law—those most disadvantaged and in greatest need typically have last access to good quality services.[19] The cumulative disadvantage evident in both settings for all outcomes (Figure 3) suggests more comprehensive and equity-focused approaches are required to reduce inequalities and achieve the aim of UEH.

Some unpredicted insights also emerged. Men were not uniformly better off than women and certain subgroups of men in Pakistan (illiterate rural and urban dwellers) experienced the worst levels of cataract blindness (Figure 1), while more socially advantaged women (literate urban dwellers) fared better than disadvantaged men in all outcomes (Figures 1 and 2). Indeed, in Nigeria, literate, urban women fared best in all three outcomes. Such differences highlight the benefit of exploring social axes beyond gender, as well as emphasizing the more nuanced picture that emerges beyond the standard multivariate 'risk factor' analysis, which previously identified associations between female sex and cataract blindness and CSC in both settings (Table 1).[8,14-16]

Moving beyond unidimensional analysis of social position was an approach included in the Equity-Focused Health Research Agenda developed by a World Health Organization Task Force on Research Priorities.[20,21] We believe this is the first example of such an approach in eye health. The enhanced value of more finely-grained information on inequalities, as presented here, is that it provides evidence of specific forms of disadvantage, throws up new questions for research, and facilitates the targeting of interventions to those who have the potential to benefit most.[11,22]

Our analysis must be interpreted in relation to several potential limitations. First, the surveys upon which these analyses were based were completed several years ago, and should not be interpreted as representing the current situation in these countries. The data are nevertheless illustrative, may well hold true in the countries studied as well as many others, and provide a baseline to assess future inequalities in these countries. Furthermore, this study demonstrates the types of analyses that are likely to be of value in blindness surveys in the pursuit of UEH.

Second, despite the fact that these surveys are amongst the largest eye surveys undertaken in LMICs, the size of some subgroups was small, resulting in large 95% confidence intervals around the estimates. Finally, a hierarchical socioeconomic variable from which to construct wealth quintiles was not collected in the surveys, so commonly used inequality measures could not be calculated and we had to rely on simple measures (RD and RR). Despite this, inequalities were evident across the social axes explored, reinforcing the need to undertake more finely-grained analyses to identify the subgroups of the population with the greatest needs along with potential to benefit from service improvements.[21]

There is also much that could be learned from positive outcomes. For example, how did Pakistan achieve near universal CSC for the most advantaged men, and has this been sustained? Furthermore, how can the quality of cataract surgery be improved for everyone while also extending, accelerating and prioritising good quality services to those most disadvantaged?

The promotion of UEH is an important contributor to achieving universal health coverage. For UEH to be achieved the prevalence of cataract blindness must be reduced, as well as its unequal distribution addressed. Importantly, cataract blindness can be ameliorated at relatively low cost and with substantial benefits to individuals and societies.[23] More evidence on how and with whom to intervene is required if we are to reduce unfair and unacceptable gaps that arise from social and economic disadvantage.[24] The analysis approach presented here contributes to filling the evidence gap by identifying the nature and extent of inequalities within populations. Such evidence provides insights into how best to design and evaluate scalable interventions and should help inform policymaking.[25] It is now up to societal, health and research leadership to identify and prioritise those most disadvantaged and to make available to them opportunities to access interventions that may transform their lives, thus demonstrating real commitment to “leave no one behind”.

Competing interests: None of the authors has any conflicts of interest to disclose.

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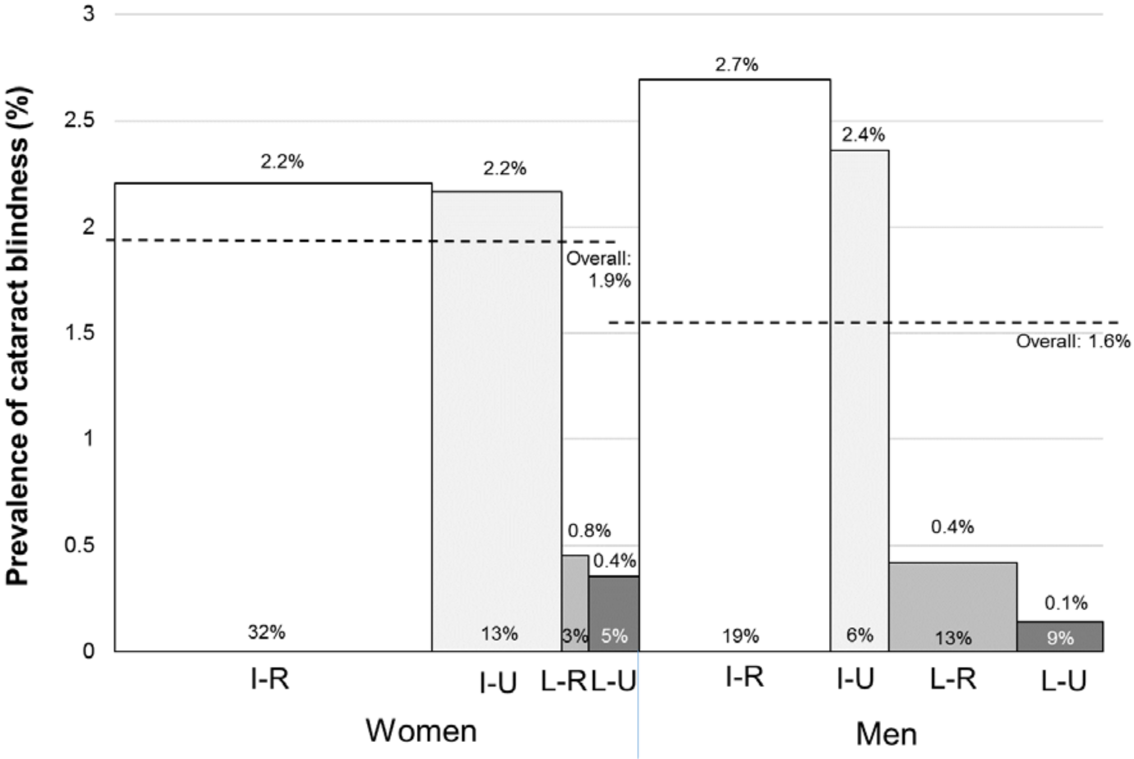
Running head: Inequality in cataract blindness and services

REFERENCES

1. Bourne RR, Stevens GA, White RA, et al. Causes of vision loss worldwide, 1990–2010: a systematic analysis. *Lancet Glob Health* 2013;1:e339-49.
2. World Health Organization. Universal Eye Health: A global action plan 2014-2019. Geneva: World Health Organization, 2013.
3. Hosseinpoor AR, Bergen N, Koller T, et al. Equity-oriented monitoring in the context of universal health coverage. *PLoS Med* 2014;11:e1001727.
4. Murthy G, John N, Shamanna BR, et al. Elimination of avoidable blindness due to cataract: where do we prioritize and how should we monitor this decade? *Indian J Ophthalmol* 2011;60:438-45.
5. Lewallen S, Mousa A, Bassett K, et al. Cataract surgical coverage remains lower in women. *Br J Ophthalmol* 2009;93:295-98.
6. Abou-Gareeb I, Lewallen S, Bassett K, et al. Gender and blindness: a meta-analysis of population-based prevalence surveys. *Ophthalmic Epidemiol* 2001;8:39-56.
7. Carter MJ, Limburg H, Lansingh VC, et al. Do gender inequities exist in cataract surgical coverage? Meta-analysis in Latin America. *Clin Experiment Ophthalmol* 2012;40:458-66.
8. Abubakar T, Gudlavalleti MV, Sivasubramaniam S, et al. Coverage of hospital-based cataract surgery and barriers to the uptake of surgery among cataract blind persons in Nigeria: The Nigeria National Blindness and Visual Impairment Survey. *Ophthalmic Epidemiol* 2012;19:58-66.
9. Bourne RRA, Dineen B, Ali S, et al. Outcomes of cataract surgery in Bangladesh: results from a population based nationwide survey. *Br J Ophthalmol* 2003;87:813-19.
10. Syed A, Polack S, Eusebio C, et al. Predictors of attendance and barriers to cataract surgery in Kenya, Bangladesh and the Philippines. *Disabil Rehabil* 2013;35:1660-67.
11. Kelly MP. The axes of social differentiation and the evidence base on health equity. *J R Soc Med* 2010;103:266-72.
12. Dineen B, Gilbert CE, Rabiu M, et al. The Nigerian National Blindness and Visual Impairment Survey: Rationale, objectives and detailed methodology. *BMC Ophthalmol* 2008;8:17.
13. Bourne R, Dineen B, Jadoon Z, et al. The Pakistan National Blindness and Visual Impairment Survey-Research design, eye examination methodology and results of the pilot study. *Ophthalmic Epidemiol* 2005;12:321-33.
14. Dineen B, Bourne R, Jadoon Z, et al. Causes of blindness and visual impairment in Pakistan. The Pakistan National Blindness and Visual Impairment Survey. *Br J Ophthalmol* 2007;91:1005-10.
15. Jadoon Z, Shah SP, Bourne R, et al. Cataract prevalence, cataract surgical coverage and barriers to uptake of cataract surgical services in Pakistan: The Pakistan National Blindness and Visual Impairment Survey. *Br J Ophthalmol* 2007;91:1269-73.
16. Abdull MM, Sivasubramaniam S, Murthy GVS, et al. Causes of blindness and visual impairment in Nigeria: The Nigeria National Blindness and Visual Impairment Survey. *Invest Ophthalmol Vis Sci* 2009;50:4114-20.
17. World Health Organization. *Handbook on health inequality monitoring with a special focus on low-and middle-income countries*. Geneva: World Health Organization, 2013.
18. World Health Organization. Making fair choices on the path to universal health coverage. Final report of the WHO Consultative Group on Equity and Universal Health Coverage. Geneva: World Health Organization, 2014.
19. Tudor Hart J. The inverse care law. *Lancet* 1971;297:405-12.
20. Ostlin P, Schrecker T, Sadana R, et al. Priorities for research on equity and health: Implications for global and national prioirty setting and the role of WHO to take the health equity research agenda forward. Geneva: World Health Organization, 2010.
21. Östlin P, Schrecker T, Sadana R, et al. Priorities for research on equity and health: towards an equity-focused health research agenda. *PloS Med* 2011;8:e1001115.
22. Kelly MP, Bonnefoy J, Morgan A, et al. The development of the evidence base about the social determinants of health. Geneva: World Health Organization, 2006.

23. Gray Z, Ackland P. *Cataract surgical coverage. An important indicator for eye health and for monitoring progress towards Universal Health Coverage*. London: International Agency for the Prevention of Blindness, 2015.
24. Ramke J, Zwi AB, Palagyi A, et al. Equity and blindness: closing evidence gaps to support universal eye health. *Ophthalmic Epidemiol* 2015;22:297-307.
25. Bowen S, Zwi AB. Pathways to “evidence-informed” policy and practice: a framework for action. *PLoS Med* 2005;2:e166.

Pakistan



Nigeria

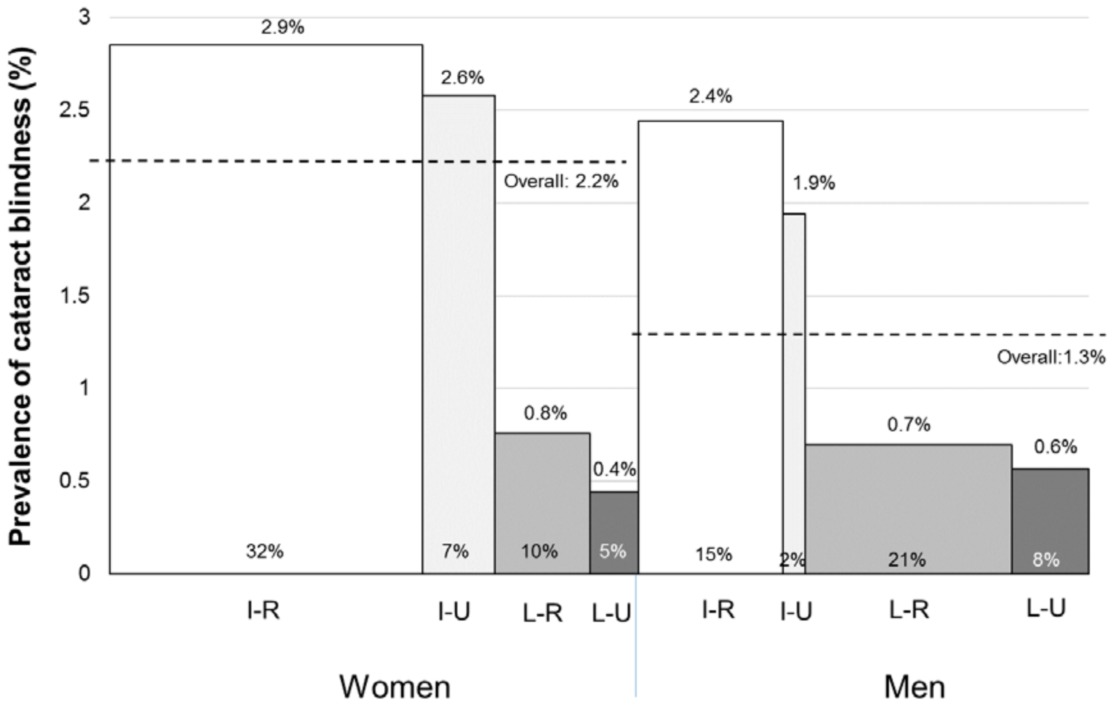
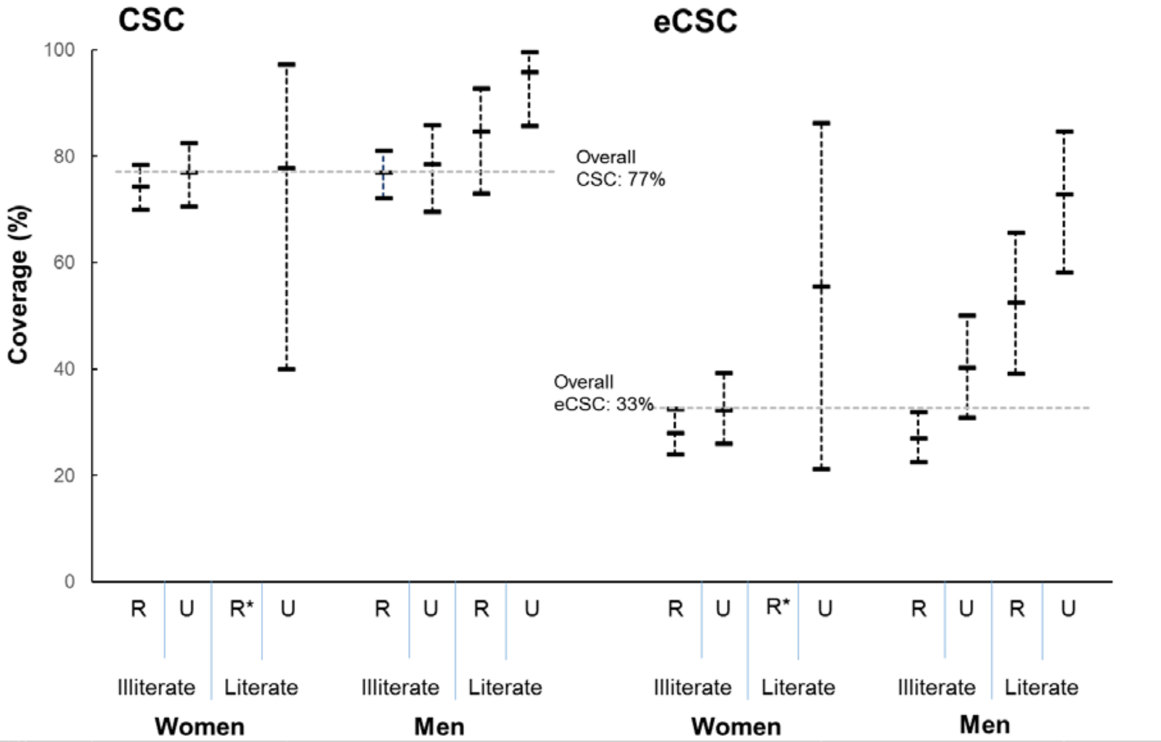


Figure 1: Prevalence of cataract blindness across social subgroups in adults aged ≥30 years in Pakistan (2001–4) and ≥40 years in Nigeria (2005–7)

I=illiterate, L=literate, R=rural, U=urban.

For each subgroup, the prevalence of cataract blindness is plotted along the y axis, and the proportion of the sample in each subgroup is indicated at the bottom of each bar e.g. for Nigeria 32% of the sample were illiterate, rural females.

Pakistan



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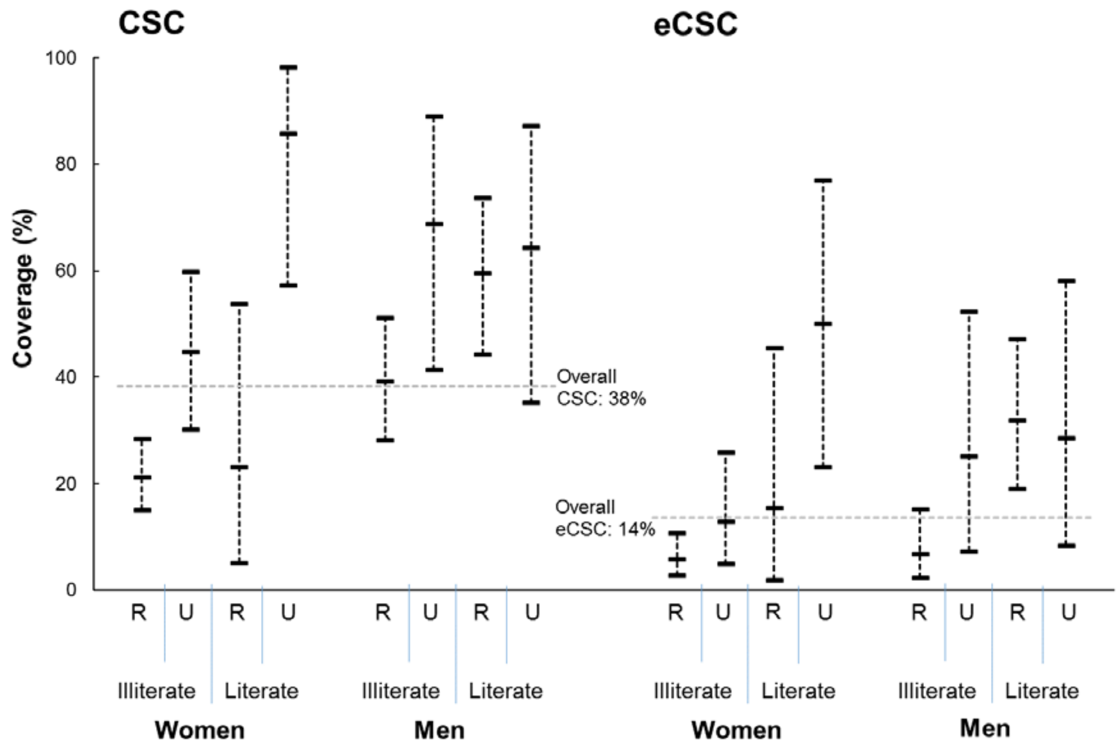


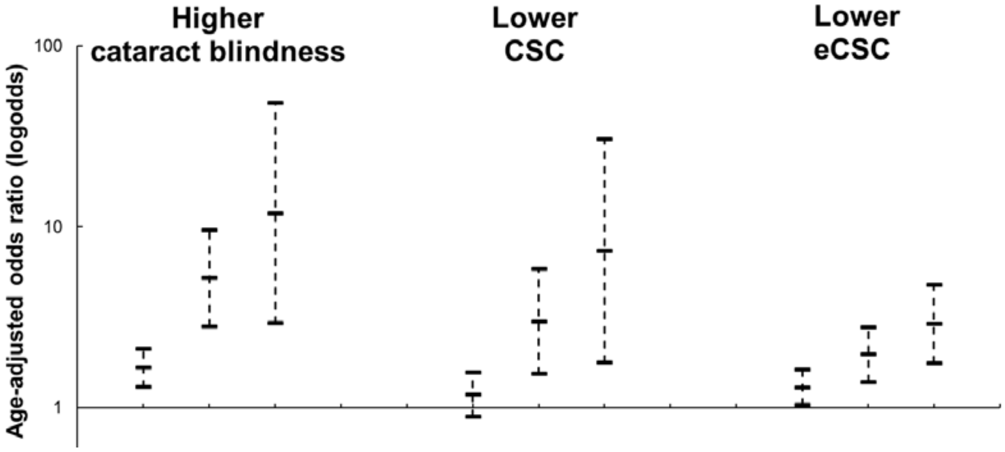
Figure 2: Cataract surgical coverage (CSC) and effective cataract surgical coverage (eCSC) across social subgroups in adults aged ≥30 years in Pakistan (2001–4) and ≥40 years in Nigeria (2005–7)

R=rural, U=urban

CSC, eCSC and their 95% confidence interval are shown by the vertical bar for each subgroup.

* Insufficient number of rural literate women in Pakistan for inclusion (n=3 cataract surgeries).

Pakistan



Nigeria

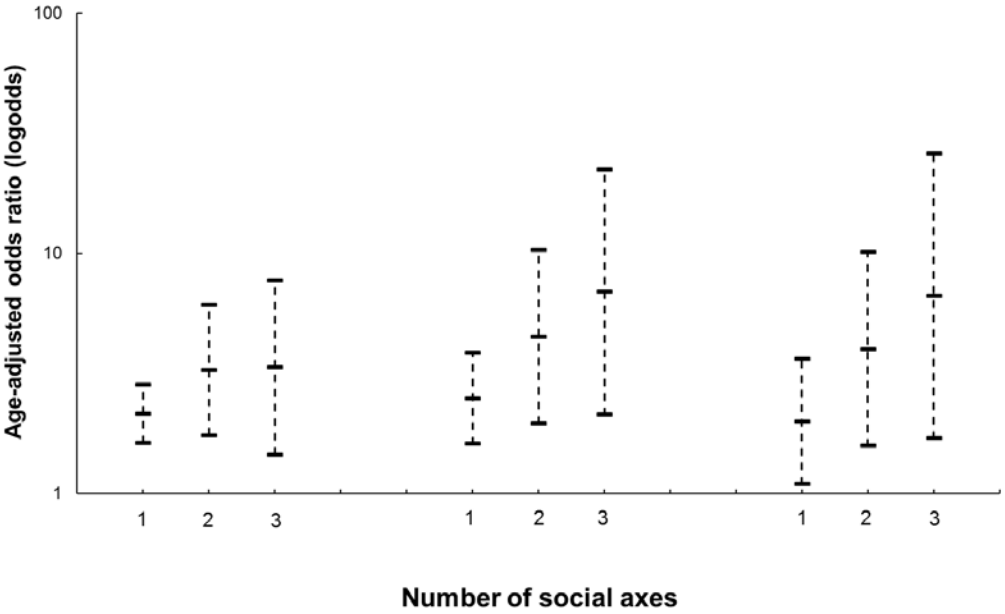


Figure 3: Cumulative disadvantage and inequality in cataract blindness, cataract surgical coverage (CSC), and effective cataract surgical coverage (eCSC) in Pakistan (≥30 years, 2001–4) and Nigeria (≥40 years, 2005–7)

Inequality was assessed by age-adjusted logistic regression, comparing the best- and worst-off in each axis combination; the odds ratio quantifies the association with i) higher prevalence of cataract blindness, ii) lower CSC and iii) lower eCSC. For all models, the chi-squared test showed no evidence of lack of fit.

1 axis=female versus male*; 2 axes= illiterate female versus literate male*; 3 axes=illiterate rural female versus literate urban male* (* indicates the reference group in the model)