Objective: To estimate and compare the incidence of operable cataract and the desired cataract surgery rates required to eliminate cataract-related visual impairment in several Latin American settings.

Methods: We obtained raw data on age-specific cataract prevalence from standardized population-based surveys. We used the data in a previously described model to estimate the incidence of operable cataract at 11 sites in 10 countries across Latin America. Age-specific incidence rates were then multiplied by corresponding population data to calculate the desired cataract surgery rates needed to eliminate cataract-related visual impairment in eyes in each country. Age-standardized incidence was also calculated to explore potential non–age-related differences in incidence among the countries.

Results: The desired cataract surgery rates ranged from 3441 to 8935 in the 11 sites. Much of the variation was owing to differing age structures, but there may be important variation in age-specific incidence rates as well.

Conclusions: Age structure has a major effect on the number of cataract surgeries needed in different countries of Latin America, and it is essential to consider this when planning cataract surgical services. Potential differences in non–age-related risk factors for cataract among different populations also deserve further study.


In the past decade, population-based surveys (Rapid Assessment of Cataract Surgical Services [RACSS] and Rapid Assessment of Avoidable Blindness [RAAB]) were conducted according to standard methods in a number of Latin American countries. These studies demonstrated that 41% to 87% of blindness (presenting visual acuity [VA] of <3/60) is due to cataract. Provision of sight-restoring cataract surgery is critical to making an impact on the prevalence of blindness and visual impairment on the continent. One measure of the provision of cataract surgery is the cataract surgical rate (CSR), which is the number of cataract surgical procedures provided per million people per year. Although this indicator has limitations, it is a simple, measurable metric of the services provided, and it is useful for planning and monitoring services. The CSR does not take into account the VA of eyes of people before surgery. However, if we assume that the cataracts being operated on are visually significant (at whatever level of VA that is defined), then when the CSR is equal to the annual incidence of cataract at that VA level over several years, a steady state situation develops and visual impairment from cataract will gradually disappear.

Therefore, data on the incidence of operable cataract would be very useful, as they can be used to set target (desired) CSRs. Unfortunately, such data are expensive to obtain and are not available for Latin America. However, there are methods to estimate incidence, and a new model to estimate the incidence of operable cataract has recently been described. This was developed specifically to calculate target CSRs using data on age-specific prevalence of cataract causing VA loss at different levels. We applied the model to RACSS and RAAB survey data from 10 Latin American countries to estimate the target CSR needed to eliminate visual impairment from cataract in each survey area. We also used the model to calculate age-standardized incidence of operable cataract at the less than 6/18 level to compare potential differences in incidence not related to age structure among the different sites.

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We contacted the principal investigators of the RACSS and RAAB surveys from Latin America to request raw data from the surveys. Details of the model to estimate cataract incidence and target CSRs from age-specific prevalence data have been described elsewhere.\(^3\) Briefly, the model classifies eyes as having cataract if there is a lens opacity responsible for VA of less than 6/18 or if the lens has been surgically removed. The model uses a compartment system to classify people as having unilateral cataract, bilateral cataract, or no cataract. People may move through the compartments or die at transition rates \(\lambda_i\) through \(\lambda_5\) as shown in Figure 1. The transition rates are determined mathematically assuming an exponential rate of change; these rates describe the incidence of unilateral and bilateral cataracts. Once incidence is determined, the corresponding CSR is determined by considering the percentage of the population older than age 50 years (those presumably at risk for cataract). The model is based on the assumptions that (1) the population is relatively closed (ie, there is no significant movement of people older than age 50 years in or out), (2) that people with cataract are biologically older and have a mortality rate 1.5 times that of those without cataract, (3) that non–age-related risk factors in a population are relatively stable over time, and (4) that most cataract operations are performed in eyes with VA of less than 6/18.

Raw data were obtained in an Excel format and used in the model just described. The proportion of people older than age 50 years for each country was obtained from 2010 data\(^4\) to calculate the CSR needed to eliminate cataract visual impairment at the level of less than 6/18.

In addition, to calculate an age-standardized incidence of cataract in those older than 50 years, we multiplied the 5-year age-group incidence of cataract (at the <6/18 level) in each survey by a standard population-age structure. The results are shown in the Table. Confidence intervals were calculated by bootstrapping with 500 iterations.

Of 13 surveys identified, we were able to get raw data from 11. For each of the 11 sites, the incidence of cataract causing VA of less than 6/18 in the eyes of people older than age 50 years is shown in the Table. The target CSR needed to operate on the incident cataract eyes is also shown in the Table and is based on the incidence and percentage of the population in the country that was 50 years and older. The target CSR varied from 3.441 in Mexico to 8935 in Cuba. The assumption is that the sample in the survey is generally representative of the people in the country in terms of non–age-related factors that determine the incidence of cataract (eg, UV exposure or smoking). Two surveys were available from Argentina and the incidence rates were very similar for these.

The estimated target CSR needed to operate on all eyes with cataract at the less than 6/18 level is compared with the actual CSR in the country in Figure 2.

**METHODS**

**RESULTS**

The most striking finding from this analysis is the large variation in cataract surgical needs among these sites. There are several factors that determine what the target CSR needs to be to eliminate cataract as a cause of visual impairment and blindness. Because CSR is defined as the number of cataract operations done per million population, the age structure of the population in question will obviously be important. All other things being equal, a population with 20% of people older than age 50 years will need a target CSR twice that of a population with 10% older than age 50 years. In Latin America, the proportion of people older than age 50 years varies greatly among countries; in this series of surveys, it ranged from 12.3% in Guatemala to 30.6% in Cuba. This variation alone accounts for a large part of the differences in CSR required to eliminate cataract visual impairment. The importance of age structure has been noted before, and it is critical to take these variations into account when planning.\(^5\)

The population structure can also vary within countries at the level of the VISION 2020 initiative planning areas. An example of this is Chaco, Argentina, where around 18% of the population is older than age 50 years compared with a national average of 26%. According to this model, the required CSR for Chaco would be 18/26 of the CSR estimated for Argentina as a whole, or 0.69 \(\times\) 5254 = 3625. A previous estimate for Chaco, based on a different model, was that the target CSR required to eliminate cataract visual impairment at the level of less than 6/18 would be 3973.\(^7\) This is similar to our finding, although the models are based on different assumptions and constructed very differently.\(^7,8\) It is beyond the scope of this article to discuss the differences.

Variations in the age structure within the population older than age 50 years will also influence the incidence to some extent because countries with a large percentage older than 50 years may also have a larger proportion of the very oldest, who develop cataract at the highest rates. For this reason, we created a standard age structure and applied the age-specific incidence rates for each survey, allowing us to explore potential differences in incidence among the sites that are related to the age structure. While age standardization justifies to some extent the extrapolation of incidence data from one district to an entire country, such extrapolation requires caution. It does not take into account the known non–age-related risk factors for cataract incidence, such as genetics, lifestyle, or ecologic factors,\(^8\) all of which might vary among districts of a country. There has also been increasing understanding of the role that genetics plays in cataract formation in the past decade;\(^10,11\) thus, it is interesting that our analysis found the highest incidence rates in Peru and Guatemala—countries with large proportions of indigenous people. However, ethnicity is a complex issue in Latin America, and we can only speculate on its potential role. Differences in specific risk factors for cataract, such as smoking or UV exposure, could also account for differences in...
age-standardized incidence among populations including populations in different districts of the same country.

There are important limitations in this analysis, some related to the RAAB and RACSS data and some to the modeling. Neither RAAB or RACSS were designed to detect lens opacity per se; rather, they were intended to detect operable cataract as judged by the examiner. In terms of estimating the CSR, this is not a disadvantage because operable cataract and not lens opacity is the condition of interest. For example, if there were a high prevalence of retinal pathology in a population that caused a surgeon to judge many lens opacities to be inoperable, the model would underestimate the incidence of cataract.

When speculating about variations in incidence among the survey populations, it is important to remember that the incidence estimates were modeled and not measured directly. Our results should be interpreted in light of the 4 modeling assumptions previously noted, each of which is discussed briefly here. (1) If there is a great deal of movement in and out of the population among those older than age 50 years or the differential mortality already conferred by having cataract is exaggerated by war or other conflict, we may get an unrealistically low incidence estimate, such as we reported in a post-conflict zone in Burundi.12 (2) The actual differential mortality for those with cataract compared with those without cataract is not known and estimates have varied.13 We reported previously that increasing the differential mortality from 1.5 to 1.75 results in a 12% increase in incidence, while decreasing it to 1.25 reduces incidence by about 12%.3 (3) The prevalence of risk factors for cataract, such as smoking or diabetes, could increase over time in a population, and this would lead to an underestimate of incidence, although it is beyond the scope of this article to quantify this. (4) The model will overestimate incidence in settings where a large number of eyes are operated on when the VA is greater than 6/18. This is more likely in more developed settings, but we have no data on the preoperative VA in any of the Latin American sur-

Table. Data Derived from the Rapid Assessment of Cataract Surgical Services and Rapid Assessment of Avoidable Blindness Surveys

<table>
<thead>
<tr>
<th>Country of Survey, District</th>
<th>Study Year</th>
<th>Incidence, Eyes/100 People/y in Sample (95% CI)</th>
<th>Proportion of Population ≥50 y Countrywide in 2010, %</th>
<th>Estimated Target CSR Countrywide</th>
<th>Reported CSR Countrywide in 2010</th>
<th>Age-Standardized Incidence, Eyes/100 People/Y (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina, Buenos Aires</td>
<td>2003</td>
<td>1.99 (1.73-2.22)</td>
<td>26.4</td>
<td>5254</td>
<td>2622</td>
<td>2.93 (2.44-3.49)</td>
</tr>
<tr>
<td>Argentina, Chaco</td>
<td>2008</td>
<td>1.81 (1.54-2.04)</td>
<td>26.4</td>
<td>4778</td>
<td>2700</td>
<td>2.65 (2.15-3.29)</td>
</tr>
<tr>
<td>Brazil, Campinas</td>
<td>2003</td>
<td>2.69 (2.43-2.96)</td>
<td>21.0</td>
<td>5649</td>
<td>2700</td>
<td>2.78 (2.37-3.32)</td>
</tr>
<tr>
<td>Chile, Bio-Bio</td>
<td>2006</td>
<td>2.05 (1.84-2.26)</td>
<td>25.9</td>
<td>5310</td>
<td>3450</td>
<td>2.69 (2.26-3.15)</td>
</tr>
<tr>
<td>Cuba, Havana</td>
<td>2004</td>
<td>2.92 (2.65-3.15)</td>
<td>30.6</td>
<td>8935</td>
<td>2428</td>
<td>3.00 (2.57-3.36)</td>
</tr>
<tr>
<td>Dominican Republic, country</td>
<td>2008</td>
<td>2.17 (1.98-2.40)</td>
<td>18.1</td>
<td>3928</td>
<td>1247</td>
<td>2.98 (2.63-3.37)</td>
</tr>
<tr>
<td>Ecuador, country</td>
<td>2008</td>
<td>3.32 (3.16-3.48)</td>
<td>18.0</td>
<td>5976</td>
<td>1490</td>
<td>3.67 (3.30-3.99)</td>
</tr>
<tr>
<td>Guatemala, 4 provinces</td>
<td>2004</td>
<td>3.54 (3.41-3.69)</td>
<td>12.3</td>
<td>4354</td>
<td>990</td>
<td>4.18 (3.90-4.43)</td>
</tr>
<tr>
<td>Mexico, Nuevo Leon</td>
<td>2005</td>
<td>1.86 (1.59-2.12)</td>
<td>18.5</td>
<td>3441</td>
<td>1550</td>
<td>2.68 (2.20-3.30)</td>
</tr>
<tr>
<td>Peru, Piura and Tumbes</td>
<td>2002</td>
<td>3.09 (2.88-3.37)</td>
<td>17.5</td>
<td>5408</td>
<td>1400</td>
<td>3.88 (3.54-4.19)</td>
</tr>
<tr>
<td>Venezuela, country</td>
<td>2004</td>
<td>2.37 (2.14-2.57)</td>
<td>17.9</td>
<td>4242</td>
<td>3483</td>
<td>3.53 (3.13-3.99)</td>
</tr>
</tbody>
</table>

Abbreviation: CSR, cataract surgical rate.

a Target CSR for the country assumes that the districts surveyed were representative of the entire country in terms of the non-age-specific factors that determine cataract incidence. The target for a particular district in the country should be adjusted to make it proportional to the percentage of the population older than age 50 years in that district compared with the proportion in the entire country.

b Reported CSR in Cuba and Venezuela may be too high because foreign patients were included in the numbers. Some patients from mission hospitals were not included in the data from Peru and Guatemala.3

Figure 2. Target cataract surgical rates (CSRs) to operate on all eyes with visual acuity of less than 6/18 vs reported actual CSRs.
veys. The relationship between the proportion of eyes operated on at VA of greater than 6/18 and the resulting overestimation of incidence is linear, increasing as the proportion itself increases. The slope of the line depends on the cataract surgical coverage, and it is steeper when the coverage is higher. To summarize, limitations and assumptions in the model could account for some of the differences in the age-standardized incidence rates that we described here. On the other hand, our results may reflect real differences among the populations at risk for developing cataract, either owing to genetic, environmental, or cultural factors.

Incidence studies of the sort needed to validate the model have not been done except for a small study in Uganda, which reported results consistent with the model. The basic premise of the model was suggested more than 25 years ago and validated in a study of incidence of open-angle glaucoma. Improvements in the capacity to perform complex calculations by computer programs allowed development of the 4-compartment model to account for the fact that cataract can be a unilateral or bilateral condition; this is critical when estimating how many cataract operations need to be done.

The gap between the target CSRs to operate on all eyes at the less than 6/18 level and the actual CSRs reported in 2010 is large in many countries. This target is for all eyes at the VA level of less than 6/18. If it were known that 30% of the operations were done on second eyes, then a CSR 30% lower could still result in every person having an operation. However, it is accepted that good-quality second eye surgery is beneficial, and the percentage of people who want a second eye operation is likely to increase if services are of good quality. Thus, we suggest planning for all eyes. It is also true that in some countries it may be that eyes are not operated on until cataract causes severe visual impairment (VA ≤ 6/60 and ≤ 3/60) or blindness (VA < 3/60). The target rates to reach eyes at this level, as predicted by our model, are roughly one half of those at the less than 6/18 level. We did not present these data here because the modeling at the level of less than 6/18 is more accurate, therefore more suitable for cross-country comparisons. Furthermore, it is increasingly recognized that many people require and will want cataract surgery before they become severely visually impaired or blind and, in the long term, we think planning needs to be done for this.

Despite the limitations, we believe there is new and useful information provided in this analysis. The large variation in population structure among countries in Latin America means that the numbers of cataract operations needed will vary significantly by country and by district within a country. Most districts will not have a RAAB or RACSS survey, but using the incidence from the country, then adjusting the CSR for age structure should provide better information for planning than has been available. These numbers should not be viewed as absolute predictors of how much surgery needs to be done. Rather, they may serve as useful guidelines for planning and some aspects of monitoring. Alone, they tell us nothing about the distribution of services within a country and nothing about the quality of the services. Reducing the prevalence of cataract blindness is more about the quality of surgery than the quantity.

Recognition of potential differences in age-standardized incidence among populations may provide impetus for more investigation into risk factors for cataract.

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