A treatment is available that can substantially reduce the rate of unfavourable outcomes, but surveillance for the disease is required

Some other obstacles to the study of the epidemiology of ROP are not so obvious. Equipment used to treat ROP retinopathy, is unfamiliar to practitioners, and/or periodically requires servicing. Reliable haemoglobin saturation monitoring is highly problematic. In the United States it may take days to find appropriate personnel to repair broken laser equipment. This sort of support simply does not exist in the developing world. Recognition of ICROP (International Classification of Retinopathy of Prematurity) diagnostic findings requires ongoing review and calibration of doctors. Physical findings and management of ROP and its prevention are debated even in the Western world. Meanwhile, emerging economies are visited by Westerners with varying opinions about ROP classification findings, treatment timing, management of oxygen, management of other medical issues, use of oxygen, antioxidants, light in the nursery, respirators, and so on.

By now, the reader may be feeling less than sanguine about the potential for reducing the prevalence of blindness from ROP in emerging economies. Along comes the enlightened article by Chen and Li published in this issue of the *BJO* (p 268) to offer more than just a glimmer of hope that ROP can be studied and treated. Although these authors raise the spectre that a new epidemic of ROP may be emerging, they indirectly demonstrate that screening

programmes are slowly coming into existence, at least in major metropolitan areas.

Implied in this paper is the fact that ROP surveillance has attained an important status in some regions of China. To be sure, it is very alarming that zone I cases are occurring, but recognition of these cases is the first step in prevention and management. It is also a concern that larger birthweight infants may develop severe ROP. Here, too, understanding the epidemiology of ROP in this part of the world will lead to better diagnosis and treatment.

The Western world has much to learn from research emanating from the developing world. To the extent that the epidemiology in these regions differs from that in the Western world, these differences may serve as a basis for understanding what initiates the disease, and what reduces its incidence. In the United States, the incidence of the disease has not changed much in the past 15 years, despite significant medical advances in the care of preterm infants.⁴ Chen and Li suggest that imprecise use of oxygen could be a factor in the apparently increasing incidence and severity of ROP in China. This is a plausible explanation, and one that might explain how and why ROP should occasionally be so severe in larger and more mature infants. Could oxygenation policy in the United States affect the incidence of the disease?

The fact remains that ROP is recognised with increasing frequency in developing regions of the world. A treatment is available that can

substantially reduce the rate of unfavourable outcomes, but surveillance for the disease is required. Chen and Li are to be congratulated for studying the incidence of ROP in their country, and for bringing to our attention the alarming observation that many infants are blinded by ROP in China. Exactly how such surveillance should occur in China and other developing nations will depend on local factors. The first step in reducing blindness from ROP is recognising that the problem exists.

Br J Ophthalmol 2006;**90**:254-255.
doi: 10.1136/bjo.2005.081166

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Visual impairment

The calculation and use of economic burden data

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Even in a developed economy, visual impairment can limit further economic development

Taylor *et al* writing in this issue of the *BJO* (p 272) are to be congratulated for their excellent description of the economic burden of visual impairment in Australia. While most in the eye care community have always assumed that visual impairment represents an important social burden, the authors have

shown that the absolute economic burden of visual impairment ranks with cancer, dementia, and arthritis. The impact relative to the entire Australian economy (0.6% of the Australian GDP) also emphasises the non-trivial nature of the burden of visual impairment. The results should catch the attention of

health policy makers because they suggest that, even in a developed economy, visual impairment can limit further economic development.

In order to make appropriate use of the important findings, readers must understand the inputs into the burden calculation, the way in which a measure of burden can fit into cost effectiveness or cost benefit models, and notable points about the methods used. Epidemiological and economic data are inputs for a national burden calculation. The epidemiological information is either prevalence or incidence; Taylor *et al* used prevalence, and this has implications for how the results can be incorporated into an economic evaluation. The economic data include expenses related to prevention and treatment of conditions leading to visual impairment, productivity loss among the visually impaired population, and expenses attributable to informal

care. The inputs suggest that in the absence of vastly improved methods of preventing the incidence or progression of cataract, glaucoma, age related macular degeneration, and diabetic retinopathy, the national prevalent burden will grow over time in ageing populations unless the economic costs per person are reduced.

When prevalence data are used to calculate burden (as in the paper by Taylor *et al*) the burden of illness measure, no matter how large the absolute or relative burden, cannot be used alone to provide an economic rationale for treatments or interventions. Thus, while Taylor *et al*'s work provides critical insight into the impact of visual impairment on the economy, more or different information is needed to use the results in an economic evaluation. There are three ways in which this might occur. Firstly, if all visual impairment were eliminated, a national burden figure describing all the costs avoided could be compared with the costs of eliminating visual impairment; this, however, is an unrealistic clinical outcome for the foreseeable future. Secondly, an economic evaluation could compare a change in the national burden over time with the costs of the programme necessary to achieve that change.¹ Thirdly, the cost of illness calculation could be incidence based. Incidence based measures are at the patient level and describe the expected lifetime costs of an incident case. The lifetime costs avoided could be compared with the costs of preventing one case of visual impairment in an economic evaluation. Alternatively, incidence based cost of illness estimates at different ages could be compared to describe the costs avoided by slowing the progression of a condition like glaucoma. Until one of these three conditions holds, those performing economic evaluations must proceed with caution.

The absolute economic burden of visual impairment ranks with cancer, dementia, and arthritis

None of this is intended to detract from the high quality cost of illness study that was conducted. Rather, it reflects the need for consumers of cost of illness literature to understand what else is needed to inform economic evaluations and not misuse the results. One potential misuse of the findings would be to divide the national burden by the number of blind people to obtain a patient based estimate of the annual cost. This would be a misuse of the results because the direct and indirect costs will undoubtedly vary with age, severity of visual impairment (that is, "legal blindness," counting fingers, no

light perception), and the underlying illness that results in visual impairment. If the results can be extended to report on subgroups by condition and age, the findings would fit much more immediately into economic evaluations.

Although the results cannot be used directly in an economic evaluation without further information, two methodological points are notable and make the study appropriate as an input into a cost-benefit study. Cost-benefit studies are preferred by some economists as they provide a theoretically driven answer to the question: does a new programme increase societal welfare?² However, these studies are often not preferred by non-economists who find both the economic interpretation of "welfare" and the necessity of placing a monetary value on human life to be controversial. Despite the controversy and its general non-use in medical care evaluation, placing a monetary value on human life is common in environmental health and safety economic evaluations.^{3,4}

Taylor *et al* converted the "loss of wellbeing" described by years of life with disability and years of life lost as a result of premature mortality into a monetary figure despite the controversy. This conversion deserves careful consideration. Money is easier for policy makers to interpret than disability or quality adjusted life years (DALYs or QALYs). However, many conducting health economic evaluations rely on "years of life saved" or "cases of blindness prevented" to avoid the controversies of valuing human life.

The authors begin the conversion from loss of wellbeing to a monetary figure by summarising the years of life with disability and the years of life lost in DALYs, which were then converted to a monetary value using the monetary value of a statistical life year. The "value of a statistical life" is a measure often derived from data on trade-offs that individuals make in a market. Commonly, when two occupations require similar skills but one has a higher risk of mortality, we assume that those who work in the job with the higher mortality risk would be paid more to compensate for the risk. Researchers infer the value of a statistical life from data on different mortality risks and wage rates. The value of a statistical life year can be obtained by incorporating life expectancy. Some may find unattractive the fact that the derivation does not produce a value of a statistical life year that depends on the age of the person experiencing the life year.

For those familiar with the discussion of societal willingness to pay for an

improvement in QALYs, it is important to note that the "value of a statistical life" is an analogous, but not identical, concept. The willingness to pay for more QALYs is a value judgment made by a decision maker. The value of a statistical life is commonly a function of market behaviour rather than an assumed societal, politically driven value of quality of life or disability. The value of a statistical life year tends to be higher than the amount that society is thought to be willing to pay for an increase in QALYs.⁵ As the monetary value of the loss of wellbeing is approximately one half of the burden, the magnitude of the monetary value per year of life is critical. Smaller monetary values of a year of life would make the loss of wellbeing a smaller portion of a smaller total burden. However, using commonly quoted measures of societal willingness to pay (for example, US\$100 000 for a QALY), the prevalent burden of visual impairment in Australia would remain significant.

To Taylor *et al*'s credit, they also were analytically correct in their careful treatment of "transfer costs." In health economic analyses, the social perspective is usually the default. This means that when considering the burden of disease, we are concerned with incremental uses of resources (or benefits) that would not be present in the absence of the disease. The somewhat counter-intuitive consequence of this is that support payments for individuals with disabilities are not considered to be a cost. Rather, these are simply a transfer of who holds the money—that is, from a "well" taxpayer to the "sick" person no longer paying taxes. This has been a limitation of previous studies that treated such payments as a social cost.⁶

In conclusion, Taylor *et al*'s results alone will help to raise consciousness of the burden of visual impairment in developed economies. Understanding the next steps that need to be taken to make appropriate use of the impressive burden findings in economic evaluations will help those trying to advocate for increased resource allocation to eye care in the future.

Br J Ophthalmol 2006;**90**:255–257.
doi: 10.1136/bjo.2005.084848

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Eye infection

Polymicrobial infection and the eye

S Tuft

Has important management implications

Treatment for infection is typically determined following an assessment of the clinical features of the disease, the likely causative pathogen, and the spectrum of activity of the available drugs. This treatment can be modified subsequently when the results of clinical investigations are available. It would simplify management if each infection were caused by a single pathogen that was amenable to treatment with one antimicrobial agent. Unfortunately, multiple pathogens may be present and they may interact to confuse the clinical picture. Simultaneous or sequential polymicrobial infection can occur, both with similar organisms (for example, different species of bacteria) and with organisms from completely separate kingdoms (for example, bacteria, fungi, acanthamoeba) or non-living viruses.¹ The presence of a polymicrobial infection has important management implications because it will modify the clinical course of the disease and the anticipated response to treatment. With the exception of topically applied antiseptics, the antimicrobials used in ophthalmology do not have a significant activity across groups of potential pathogens. Polymicrobial infection may be missed unless specific investigations are performed to identify all potential participants in the disease process, and protocols may need to be developed for effective treatment. Although polymicrobial infection in ophthalmology has been reported previously the clinical impact has received little attention (table 1).

The reported incidence of ocular polymicrobial infection varies widely. In part this is a result of differences in the criteria used to define an organism identified by microscopy or in culture as either a pathogen or a contaminant. Polymicrobial isolates from cases of

suppurative keratitis are reported in up to a third of cases, the majority due to multiple bacterial species.² Polymicrobial isolates have also been reported from 33% of scleral explants removed for suspected infection.³ Abscesses potentially contain anaerobic conditions and they typically yield a variety of the organisms found on skin or mucous membranes,⁴ with polymicrobial infection reported from 45% of cases of dacryocystitis⁵ and sub-periosteal abscess.⁶ In this issue of the *BJO* Pate *et al* (p 289) report that 20% of positive cultures from cases with fungal keratitis were co-infected with bacteria. There was a propensity for this to occur with candida isolates co-infected with staphylococcal bacteria, with a risk of polymicrobial infection that was approximately three times greater than with infection with filamentous fungi. They suggest that this may be because

the bacteria are protected within the biofilm produced by the candida.⁷ Whether this synergism contributes to the generally poor prognosis for fungal keratitis is unknown. In their laboratory they have also established criteria based on multiple identification by microscopy or culture to try to define whether an isolate is likely to be a pathogen. These criteria reflect the bacterial load in the wound but do not give any weight to the virulence of the organism, despite the fact that the presence of some types of organisms is usually considered significant if identified by any means.^{8,9} Their results also confirm that the use of multiple investigational techniques and media may be required to identify all possible pathogens.¹

Polymicrobial infections can become established by various means. When multiple organisms are present in the environment, trauma can result in inoculation and simultaneous (parallel) infections. In contrast, sequential or super-infection with a second organism may occur in an eye that has been put at risk by another pathogen. For example, a herpetic corneal ulcer can allow microbial adherence by bacteria or fungi that can then also cause infection, particularly if the local immune response has been inhibited with topical steroid. In this situation the opportunistic infection may be with an unusual

Table 1 Principal polymicrobial infections and ocular disease

	Causal agent	Association	Disease
Simultaneous infection	Acanthamoeba	Bacteria	Keratitis
	Fungi	Bacteria	Keratitis
Sequential infection	HTLV-I, II, III	Herpes virus, bacteria, fungi	Keratitis
		Cytomegalovirus	Retinitis
		Toxoplasmosis	Retinitis
		Cryptococcus	Retinitis, uveitis
		Pneumocystosis	Retinitis, uveitis
		Microsporidium	Keratitis
		Bacteria, fungi	Keratitis
	Herpes simplex virus	<i>Strep pyogenes</i> (Gp A)	Invasive skin necrosis (necrotising fasciitis)
Synergistic infection	Herpes zoster virus		Keratitis
	Measles virus	Herpes simplex	
	<i>Onchocerca volvulus</i>	<i>Wolbachia</i> spp	Onchocerciasis
Associated infection	<i>Chlamydia</i>	<i>Gonococcus</i> , <i>Treponema</i>	Conjunctivitis
Microbial interference	None identified to date		