Global cost of poor vision

As variable focus lenses are in the news again, **Professor Joshua Silver** shares his experience developing such lenses and argues how they may offer a solution to the major global problem of uncorrected refractive error

Figure 1 Adaptive eyewear developed by the author

There is growing awareness that uncorrected refractive error leads to a very large loss of global GDP. One recent estimate puts the global loss at over $200bn,[1] but this estimate is very likely to be significantly low, because it assumes an effective global 'need' for spectacles for around 700 million people which is very likely itself to be an under-estimate since it uses, in part, the World Health Organization (WHO) definition of visual impairment which is 'a visual acuity worse than 6/18 in the better eye'.

It is probably worth considering this point (and writing as a physicist, I pose the question to eye care practitioners reading this article) – if a person presents with an unaided vision of less than 6/18 in their better eye which is correctable to 6/6, would you not correct them?

Rather than go into the somewhat 'political' definitions which can arise in such a debate, it seems perhaps better when making an estimate of global need to adopt a simple approach and to postulate that people need distance vision correction if their unaided distance vision acuity is worse than 6/6 in the better eye, and that they also need vision correction if they are presbyopic.

By considering the fraction of people who wear corrective eyewear in developed world populations, we can actually then make a rough estimate of global need. Some two-thirds of people in the developed world have some form of correction for refractive error, so by extrapolation this suggests a global need of 4.7 billion. Industry figures suggest that in total some 1.7 billion people already have some form of vision correction, so that the unmet global need is about three billion, which is roughly four times higher than the figure used to establish the GDP loss of $200bn – suggesting that the true economic cost to the world of uncorrected refractive error could be as high as approximately $800bn.

This is clearly a global problem which must be tackled as a very high priority, given the importance of clear vision for so many different areas of life – including but not limited to health, education, earning capacity and quality of life.

Self-refraction

It is worth asking why there are so many people in the world today who need vision correction to see clearly. I would suggest that the main reason for this is that the developed world's model for the delivery of vision correction cannot be applied to large populations in the developing world, because that model depends upon access to eye care professionals, and there are simply way too few to meet the needs of the people in the developing world. Of course there is a also shortage of money for eyewear, and an absence of appropriate vision care infrastructure in the developing world. In a way, the simplest and most obvious way to deal with this problem would be to create inexpensive spectacles (we might call them 'self-refraction' spectacles) which have the property that the wearer can easily and accurately adjust them to correct their own refractive error.

Reading the literature[2] one finds that this idea goes back a long way, with the first self-refraction device having been invented and patented in 1879 by Dr Cusco. Dr Cusco's dynamoptometre was too large to be worn, and was apparently meant to establish a patient's refraction.

So can this simple and obvious approach really work? I would venture to say that the simple answer, from what is already known today, is yes and perhaps my route to this conclusion will be of some interest to readers.

My own work on self-refraction started in earnest in 1985, when on May 13 I drew up and had made for me a simple fluid-filled membrane lens. This was one of a series of prototype variable power lenses I made in 1985, but the rather special feature of the lens made on May 13 was that it used a trick I had learned from my atomic physics research in the 1970s, whereby I used two compressed rubber o-rings to seal and stretch thin polyester sheets.

You can see the actual prototype lens in operation on YouTube[3] and it has the feature that if you fill the lens with water and then change the volume (for example with a connected syringe) the surfaces of the lens change their curvature, so one has a lens of variable power where the position of the plunger in the syringe controls the power.

The most natural thing to do with a lens is to look through it, and when I did this in May 1985, I discovered that I could correct my -1.50DS myopia with very good accuracy. I could do that without the intervention of any eye care professional, and also do it with a lens which had only cost me pennies to make.

Appliances for the developing world

A natural development from a single hand-held lens which one can use for self-refraction is to make a pair of spectacles equipped with two such lenses and so, some eight years later I drew up and had made for me a rather strange-looking pair of self-refraction spectacles. A drawing of the device is available,[4] and the device (Figure 1) is also shown in a *BMJ* video on YouTube.[3]

Interestingly, only one of this device was ever made, but it was quite important in the evolution of my own self-refraction spectacles: on February 11 1994 I called Dr Bjorn Thylefors at the WHO in Geneva to ask him about the global need for spectacles.

I followed our conversation up with a letter on February 21 1994 which is perhaps interesting to look back on now because I wrote: 'I am a physicist and I have been developing ways of making adaptive lenses of good optical quality. I know from my own trials on myself that I can make an adaptive lens spectacle which may be used to correct my own vision very well, and I believe it should be possible, using my technology, to manufacture such spectacles inexpensively for mass use, so that populations in the developing world could, for example, obtain useful vision correction without the expensive infrastructure which is normally associated with the eye care industry in the developed world.'

Following this interaction with Dr Thylefors in 1994, I visited him in January 1996 and he tried the spectacles I had made in 1993, found they worked for him, and suggested I should run a trial in the developing world. This led to a small trial in Ghana, paid for by the UK Government's Overseas Development Agency (ODA) with a new and much more wearable better device.

The results of that small trial were rather encouraging, and they were presented at the 6th General Assembly of IAPB in Beijing by George Afenyo and me, and a report of the work entitled Vision Correction with Adaptive Spectacles was published in *World Blindness and its Prevention*.[5] The first adaptive spectacles actually worn in Africa in this trial are now in the National Collection of the British Science Museum in London.

Following this small study Dr David Nabarro of ODA (now the Department for International Development, DFID) encouraged us to carry out a larger trial which was funded by DFID. This larger, though still quite small, trial was carried out with over 200 subjects in four countries and investigated how well the adults in the trial could self-refract using adaptive spectacles which we called Adspecs. The results of the trial were presented at a Mopane Vision meeting in South Africa in August 2003, and then published.[6,7] This original work showed that the adults studied could self-refract rather well – something which was later confirmed by Kyla Smith from the New England College of Optometry in her Masters research.[8]

Self-refraction studies

Dr Don Bundy of the World Bank has known about my interest in and work on self-refraction for rather a long time – ever since we were introduced in the early 1990s, and he has long taken the view that a self-refraction approach could be helpful for children.

As early as June 2003 I wrote to Dr Bundy to ask for 'World Bank Funding' to 'research the application of a simple adaptive lens refractometer to child refraction in the developing world'. I pointed out that should this research prove successful, it would be likely to lead to a significant increase in the proportion of children whose refraction is accurately diagnosed, which in turn should then lead to many more children corrected. This would have a positive impact on education for the group of children (approximately 10 per cent according to WHO) who need vision correction and don't have it.

The dialogue with Dr Bundy led to a meeting on Child Vision held at Wolfson College, Oxford in July 2007. That meeting led to the so-called Child Self-Refraction Study CSRS[9,10,11] which set out to establish whether myopic teenagers (aged 12-18 years and up to -5.00DS myopia) could self-refract.

It is interesting to note that the principal motivation for this work was educational and partly, put simply, to establish whether self-refraction eyewear could be an educational intervention to enable young myopes to see the board in class. This is important because as many as 100 million teenage myopes are thought to have this vision problem.

The CSRS studied three groups of teenagers, two in China and one in the US. The results of the study are rather interesting in that they show that about 95 per cent of the myopic teenagers achieve a distance vision acuity of 6/7.5 if they use Adaptive Eyecare's original Adspecs, and follow the self-refraction procedure described in the research papers.

It is important to emphasise that this result does not show that self-refraction works but only that it worked well with a particular group of users and a specific device – the Adspecs – self-adjusted according to a defined procedure. Even so, since this research was with an early device capable of improvement, and we have not, as yet, tried to optimise either the self-refraction procedure or the worn device, it is probably reasonable to suggest that things are likely to improve when this is done. Hence my statement above that inexpensive self-refraction eyewear can deal with the problem of uncorrected refractive error. This, of course should be further qualified since, with the current state of technology, only spheres can be corrected, though that is also likely to change over time.

An interesting finding of the CSRS is that a very large fraction of the study population (some 95 per cent) achieves a distance vision acuity of 6/7.5 which is surprising since astigmatism is not corrected.

Another surprise in the data is that a comparison of self-refraction with cycloplegic subjective refraction[12] suggests that some of the study group see more clearly than their apparent refractive error would seem to allow. This led me to suspect that the use of cycloplegic subjective refraction as a gold standard could be misleading. A clinical trial is planned to explore this, the idea being that the dilation consequent on cycloplegia could lead to a focus shift of the eye large enough to need to be considered.

Given the importance of clear vision to the world, it is probably useful to consider what remains to be done, and maybe even attempt to quantify (very approximately, of course) what this will cost.

In my own work so far I have not yet tried to make variable focus lens spectacles with frames which are not round. However, this has already been done with both fluid-filled lenses[13] and Alvarez-Lohmann lenses,[14] though to the best of my knowledge these recent devices have not as yet been clinically tried for accuracy of refraction, acuity achieved, and visual comfort. But this work, which is essential to build an evidence base to show self-refraction is truly viable, can be expected to be done in the not too distant future.

As to cost, when I began my work on self-refraction glasses for the developing world, Dr Thylefors of the WHO told me in 1994 that it would be necessary to make eyewear for just a few dollars. I asked how many people needed glasses in the world and Dr Thylefors referred to a study he had chaired[15] and said it was about a billion. I told him I thought I had a means to solve the problem, and he said I should do it if I could, 'but you must make it cheap – about a dollar'. I said I thought that would be possible.

The future

I am now reasonably sure that it will be possible to do this, but it will require a new approach to the eyewear business model to make this eyewear available without the large margins which can be typical. Of course we also have the challenge of delivery cost (but we can take a guess at that), so let us guess that in the not too distant future we will be able to deliver self-refraction spectacles at a total overall cost of $8. Very roughly, if we use self-refraction eyewear, it will cost about $24bn to solve the problem. This might sound like a large sum, but the benefit should be an increase in global GDP which could be as high as $800bn.

With these estimates, it is important to realise of course that we are not making provision for eye health services. Were we to try to do that as well, then the literature[16] suggests that we would need to spend another $120bn to train and put in place the necessary staff and infrastructure.

Given the times of global austerity we live in, it seems self-evident, given the importance of clear vision, that the first thing to tackle is the delivery of corrective eyewear to those that need it. Of course the provision of eye health is extremely important, but this could become progressively more affordable as global GDP increases as a result of the provision of vision correction globally. ●

References

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Global cost of poor vision - references

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2. See: Variable and Progressive Power Lenses 1973 A.G. Bennett , Manufacturing Optics International **26** 88-91, see especially the item on Dr Cusco's Dynamoptometre

3. See: http://www.youtube.com/watch?v=r1rqgvbs9GQ

4. See: Fig 1 of European Patent EP 0 830 620 B1 Filed 1 June 1996. The European Patent Office kindly nominated me for the award of "Inventor of the Year 2011", citing this patent.

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10. Self correction of refractive error among young people in rural china: Results of cross sectional investigation 2011 Zhang, M et al www.bmj.com/content/343/bmj.d4767

11. Self correction of refractive error among young people in inner-city Boston 2013 Moore, B et al in preparation for publication

12. See Fig 3 of Ref 10 above

13. Eyeglasses with non-round fluid-filled variable power lenses have been developed by A. Gupta and collaborators – there are a number of recent patents, including for example A Gupta et al US Patent 8,414,121 B2 of April 9 2013

14. Eyeglasses with non-round Alvarez-Lohmann variable power lenses – see ref 2 above – are now in production by three companies, Adlens Ltd (www.adlens.com), Eyejusters Ltd (www.eyejusters.com), and Focus on Vision (www.focus-on-vision.com)

15. The Provision of Spectacles at Low Cost , 1987 World Health Organisation, Geneva ISBN 92 4 156108 4

16. See Reference 1 – which gives an "upper limit for the cost of dealing with vision impairment resulting from uncorrected refractive error of $ 28 billion over 5 years". It is interesting to note that there is some apparent confusion in the public mind about what the term "vision impairment resulting from uncorrected refractive error" really means – which is why I would suggest it is most appropriate to take the simple position that people should be corrected until they can see with an acuity of 6/6. If we do this, then we would have to provide eye-health services for around 3 billion people, and a scaling from the estimates of Fricke et al suggest this would cost around $ 120 billion.