A bout 40 million people worldwide needlessly suffer in darkness with a visual acuity of less than 20/400 in their better-seeing eye.1 The vast majority will remain without sight until they die. Cataract is one of the greatest public health challenges of the 21st century, accounting for nearly half (47.8%) of all blindness.1 The World Health Organization has estimated that 18 million people worldwide are blind from bilateral cataracts.2 The organization has also estimated that more than 85% of the world’s visually impaired live in developing countries,3 where blindness is associated with considerable disability and mortality resulting in large economic and social consequences. If efforts to treat avoidable blindness do not increase, the number of blind people worldwide may double by the year 2020.4 The provision of high-volume cataract surgery at a very low cost is needed in the most impoverished places on the planet. Paramount in this quest is reducing the price of IOLs and the consumables required for surgery.

Cataract surgery is the most commonly performed major operation in the United States. Its price at a major US academic center is $3,200 per eye. The 2010 Medicare-allowed charge is $2,160.91, including physician, facility, anesthesia, and consumable fees. The cost of a standard IOL is approximately $150. Premium lenses to correct astigmatism or presbyopia typically cost $800 on average. These prices make cataract surgery unattainable for the majority of blind people in the developing world. Recent advances, however, have given rise to high-volume, high-quality, cost-efficient cataract surgery.

BACKGROUND
The first method for dealing with blindness from cataracts was to dislocate the entire lens out of the visual axis and into the vitreous cavity. Alas, this technique of couching is still performed in Africa, particularly by native healers in Nigeria. A big advance occurred when Von Graefe began performing intracapsular cataract extraction and providing aphakic spectacles in the 19th century.

Cataract surgery’s outcomes improved with the development of microsurgery, and safety was enhanced by the advent of enzymatic zonulysis and cryoextraction. The procedure’s results and patients’ postoperative visual function remained poor, however, particularly in the developing world. The Nepal Eye Study of 1998 found unoperated cataract to be the leading cause of blindness.5 The investigators also found uncorrected aphakia from lost, broken, or never-provided spectacles and surgical complications to be the second and third leading causes of blindness, respectively. Moreover, in the remote hills without paved roads, the prismatic effects of aphakic glasses compromise functional vision even in the best cases.

A great leap forward in the treatment of cataracts came when Sir Harold Ridley recognized that a chip of the polymethylmethacrolate (PMMA) windshield of a fighter jet had remained inert in a Royal Air Force World War II pilot’s eye. This observation led to the development of the IOL. The first generation of PMMA lenses was inserted in the anterior chamber after an intracapsular cataract extraction. They led to significant morbidity with uveitis, hyphema, glaucoma, and corneal decompensation as frequent sequelae. These problems prompted great scrutiny of lens development by the US FDA and similar regulatory agencies in Europe. With the advent of the YAG laser, surgeons switched to extracapsular cataract extraction, and safer posterior chamber lenses became popular. The cost of the lens implants, however, continued to rise. By the mid-1980s, posterior chamber IOLs were the standard of care for cataract surgery in the developed world, but their cost was prohibitive in the poor nations where the majority of individuals blinded by cataracts lived. The genius of two doctors, one from India and one from Nepal, addressed these problems.

Dr. V
The first major stride toward slashing the cost of delivering cataract surgery in the developing world was made by Govindappa Venkataswamy, MD, affectionately known as...
Dr. V. He was born in a poor farming village in Tamil Nadu, India, in 1918. After tending the water buffalo in the morning, the young Venkataswamy would walk 3 miles every day to a school where he learned to write by scratching on the dirt floor of the schoolroom with a stick. Despite these obstacles, the brilliant young man earned a full scholarship to Stanley Medical College, located in the same village. Because three of his cousins had died during childbirth, he chose to specialize in obstetrics.

In his final year of training, Dr. V was stricken with a severe form of rheumatoid arthritis and was hospitalized for nearly 2 years. Agonized by constant, severe pain, he watched helplessly as his fingers and body became so deformed that he could no longer deliver babies. Dr. V found a new purpose in ophthalmology and taught himself techniques by which to perform delicate eye surgeries with special instruments that he designed to fit in and work with his crippled hands. After completing his ophthalmology residency, he entered government service.

In 1976, at the age of 57, Dr. V was forced to retire. He visited the United States and became obsessed with how McDonald’s was able to quickly and efficiently deliver millions of hamburgers of the same quality to every customer across the country. Dr. V thought of the overwhelming problem of cataract blindness and decided that he could use the model of McDonald’s to consistently deliver—quickly and efficiently—the product of excellent cataract surgery to the poor of India. Barely 5 feet 6 inches tall, thin and wiry with graying hair and a body obviously deformed that he could no longer deliver babies. Dr. V radiated a quiet, gentle confidence that rallied family members and colleagues. Less than a year out of retirement, he opened the first Aravind Eye Hospital, named for his spiritual guru, the philosopher, Sri Aurobindo.

The original 12-bed hospital in his brother’s home in Madurai flourished. Dr. V recognized that a lack of trained ophthalmologists was the biggest hurdle to the delivery of cataract surgery, with only 12,000 surgeons for India’s nearly 1 billion people. He developed an assembly line production using ophthalmic assistants and nurses to maximize efficiency for a high-volume flow. This organization allowed surgeons to work continuously with minimal delays between cases, and it provided training programs for doctors, nurses, and assistants. The Aravind system has since become the highest-volume surgical program in the world, with five large hospitals where more than 250,000 cataract surgeries are performed each year. Dr. V also developed what has been called compassionate capitalism, a system in which paying patients subsidize the surgery of destitute patients. By 2006, the Aravind hospitals had an operational income of $500,000, almost double their operational expenses, but still provided nearly 60% of the surgery for free. Dr. V also started Aurolab to economically produce, in a large volume, the high-quality supplies needed for eye surgery.

Meanwhile, in Nepal, Sanduk Ruit, MD, was developing the Tilganga model for eye care.

**Dr. RUIT**

This brilliant physician was born in a remote hillside village nestled beneath Mt. Kanchenjunga in northeastern Nepal, a 4 days’ trek from the nearest road. In a village without running water or a school of its own, he walked with his father for more than a week to reach a school in Darjeeling, where he was left at the age of 8. The young Ruit eventually earned a full scholarship to a medical school in India, followed by a residency in ophthalmology at The All India Institute of Medicine in Delhi, and a fellowship at Aravind. At that time, the free patients at Aravind received aphakic glasses, and only those who paid received IOLs. Dr. Ruit believed passionately that everyone should have the best possible care and that lens implants were essential for the poor living in mountainous regions with rough trails.

With the help of Australian charities, Dr. Ruit started the world-class Fred Hollows IOL Laboratory in Kathmandu, which began manufacturing a western-standard PMMA IOL. He also modified the Aravind model to best fit the terrain and population of Nepal. At the same time, Aurolab developed and began distributing its own excellent IOL. The result was that cataract surgery could be provided in the high-volume Asian setting for less than $20 per case. Dr. Ruit also worked with Australian and Japanese companies to lower the cost and improve the quality of operating microscopes and YAG lasers designed for the developing world.

In the developed world, the cataract paradigm was shifting to phacoemulsification, smaller incisions, and foldable lenses. Dr. Ruit considered phacoemulsification with foldable lenses impractical in poor areas with limited electricity and mature cataracts. After watching the Israeli surgeon Michael Blumenthal demonstrate his “mini-nuc” technique of cataract extraction, Dr. Ruit modified the approach so that a sutureless extracapsular surgery could be safely performed on all types of cataracts with minimal equipment. He demonstrated his method at Aravind, after which the “SICS” surgery spread across India and became the procedure of choice for the advanced cataracts common in the poorest areas of the developing world. In India and Nepal, skilled surgeons frequently perform more than 100 perfect cases per day. The highest-volume surgeon in the world, Bidya Pant at GETA Hospital in Southwestern Nepal, has many times completed more than 200 cases in a day.
CONCLUSION

In a randomized, prospective, controlled trial of SICS versus phacoemulsification in 2007, Dr. Ruit performed SICS, and phaco-chop master David Chang, MD, performed phacoemulsification. The techniques were equivalent in quality, with SICS being much faster and much less expensive. Aurolab now manufactures a full SICS kit that includes everything needed for surgery: preoperative drops, a retrobulbar needle and injectables, a drape, VisionBlue (DORC International BV, Zuidland, The Netherlands), a viscoelastic, an IOL, a subconjunctivally injectable antibiotic and steroids, an eye patch and shield, and all postoperative medications—all for a cost of $11!

Thanks to the cost recovery of the compassionate capitalism at Aravind and Tilganga, the volume of phaco procedures has grown steadily, as paying patients with less mature cataracts come for care. Both The Fred Hollows IOL Lab at Tilganga and Aurolab now manufacture top-quality foldable acrylic lenses for less than $20. Dr. Ruit has also been working with manufacturing companies to develop a less expensive, more robust phaco machine.

Through their techniques and the people they have trained, Dr. V and Dr. Ruit have restored the sight of millions. These physicians’ high-quality, low-cost cataract surgery with IOLs raises the hope of overcoming within the next 20 years the backlog of people needlessly blinded by cataracts.

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