

Adventures in Humanitarian Eye Care

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Background

Inequity in health care is one of the great concerns in the health care system in the United States but it pales in comparison to the deficient patchwork system of multiple public and private providers in Mexico. The result is that half of Mexico's 100 million citizens are uninsured and more than half of the country's annual health spending is private pay. (See Barraza-Llorens et al. for excellent summary).¹

The structure of the current health system is composed of three principal subsystems. There are a number of social security institutes that provide health insurance for those formally employed and their families. The largest of these is the Mexican Social Security Institute (IMSS). The IMSS is organized similar to an HMO. Approximately fifty million people are beneficiaries. The second organization is the Ministry of Health. The Ministry of Health has evolved into a decentralized state-level health service in facilities owned and operated by those services. There is also IMSS-administered, centrally run scheme called Solidaridad that delivers care to the rural poor. The third system is the private sector which is extraordinarily heterogeneous in quality and services. In large urban centers, excellent specialty-trained providers are found in for-profit clinics. In the rural poor areas there are unregulated and unsupervised private physicians, often without residency training, working out of individual clinics to deliver health care mostly to the uninsured.

It has been estimated that between two and three million households spend more than a third of their income on health care. This expenditure can easily lead to or exacerbate poverty. Recent estimates suggest that 40% of the population of Mexico is living in poverty. Unemployment sounds pretty good at only 3.2% but some reports suggest that 25% of the population is underemployed. The average per capita income is estimated to be \$10,700.²

The political or administrative divisions of Mexico include 31 states and one federal district. The location of the Indiana University School of Optometry (IUSO) activity has always been and continues to be in the state of Guanajuato. Guanajuato is located near the geographic center of Mexico, approximately 150 miles north northwest of Mexico City (see Figure 1). The population of Guanajuato is currently estimated to be approximately five million people. Reports

indicate rates of poverty are consistent in this state with a mix of urban and rural areas so there are approximately two million people living in poverty. In Guanajuato, the state's Ministry of Health shares responsibility with the Desarrollo Integral de la Familia (Integral Development of the Family, DIF) to provide medical services to the poor. All IUSO missions and programs have been arranged in partnership with the Guanajuato DIF. Usually the wife of the governor is president of the DIF organization.



Figure 1. Country map of Mexico showing the central location of Guanajuato.

The adventure begins

Before I present this narrative of activity in Mexico over the last fourteen years, I would like to recognize and thank the hundreds of participants who as students, staff, alumni and faculty have contributed to a series of events that have conservatively provided tens of thousands of people with eye care and the development of a million dollar year round teaching clinic that hopefully will provide not only optometric care but also increased and improved surgical care. For some measure of brevity, I cannot possibly list all the contributors to this effort and desperately hope to not slight anyone for their short or long term investment in these efforts.

The first humanitarian trip I participated in was 1993. The trip was organized by I-Care International lead by Anthony and Dorothy Guitierrez, from Joliet, Illinois. It is my understanding that IUSO students participated in a 1992 trip to Guanajuato prior to my involvement. This first trip was a combined trip of vision and hearing testing. It was my first experience with providing recycled glasses to people as the strategy for correcting refractive errors.

After that first trip, only vision testing was performed on all the yearly trips that followed. For the next few missions, the make up of the group was approximately twenty lay participants from I-Care International and about the same number of IU participants. Watching the difficulty and challenge of matching the desired prescription to the recycled spectacle inventory made it clear to me that we needed to introduce a computer database into the system and more skillful opticians. In 1996 our master optician Pam Gondry joined the mission and in 1997 we tested

the first version of the database.

The optics of humanitarian eye care

The database was based on power vectors developed by IUSO's Dr. Larry Thibos and Dr. William Wheeler of the IU Department of Mathematics.³ My interest in developing a mathematically sound strategy for comparing a target refractive correction to a inventory of glasses was joined by Drs. Thibos and Wheeler's interest in finding a mathematically sound way to apply appropriate statistics to any question dealing with refractive error (i.e., longitudinal investigations of LASIK or myopia progression). I was fortunate to participate in some of those sessions where the derivations were going on. I contributed interest and justification but no actual suggestions to the derivation. In 1997 we had half (just the minus prescriptions) of the usual seven to eight thousand pairs of glasses entered into a computer. The opinion of the group working in the dispensary on that trip was that the computerized database was a very good strategy. So for all subsequent trips a computer sorted the inventory to provide the closest choices to the requested prescription.

The following are the basic formulas for the conversion of the standard clinical prescription to power vectors. In the power vectors of Thibos and colleagues³ the clinical notation of sphere (S), cylinder (C) and axis (a) is converted to three orthogonal components M, J0, and J45 using the equations:

$$M = S + C/2$$

$$J0 = -C/2 \cos 2a$$

$$J45 = -C/2 \sin 2a$$

Those coefficients then are compared to the coefficients of every prescription in the database. A blur or blur strength is calculated to compute the vector length or error between the desired prescription and each pair of glasses in the inventory. The basic formula for comparing one eye is shown here.

$$B = \sqrt{(M_{rx} - M_{in})^2 + (J0_{rx} - J0_{in})^2 + (J45_{rx} - J45_{in})^2}$$

where B is the blur strength, subscripts of Rx indicated the prescription desired and "In" coefficients are from the inventory. If a match were desired to sort the inventory by both eyes then the blur would be calculated by taking the root of all six components being compared.

The difference or blur strength of each comparison is how the inventory is sorted. The closest choices were printed and the volunteer

would use this list as a guide to pull glasses. In addition, the database had fields for gender (of the frame) and bifocal power.

One of the early concerns was even though the three dioptric coefficients specifying the prescription were mathematically sound, would this strategy be consistent with the effect each coefficient had on vision (i.e., should there be some extra weighting in the blur strength calculation for oblique astigmatism). Our experiments tested the effect of blurring each coefficient separately.⁴ We found the reduction in visual acuity (the slope) as function of blur was similar, concluding that no special weighting would be necessary in the blur strength calculation. This issue has not been exhaustively examined, particularly considering the case where you ask the computer to match both eyes together.

In 1998⁵ and again in 2004⁶ we examined the accuracy of the matching routines and found we had developed a very good system where the mean difference of the closer eye matched was only 0.25 D and the poorer match was on the order of 0.50 D. Another great benefit that comes out of using a database is that you can improve the inventory of refractive correction on hand to more closely match the population you are serving. Initially we had inventories that had roughly equal numbers of glasses across all spherical equivalent (M) powers and we had problems where we would run out of low plus bifocal prescriptions. With the database system also collecting the target prescriptions, this issue of running out of prescriptions became much less likely. Figure 2 shows the distribution of M for approximately 2,200 patients. One can see that the mean is approximately -0.25 D and the vast majority of the prescriptions are between -5.00 to +4.00 D.

Several other questions and challenges have been addressed in the optical area related to Mexico. In general we consistently examine somewhere between 2,400 to perhaps 3,500 people in the five working days of the mission (referred to by the DIF personnel as "the campaign"). As indicated above, it seemed to continue to be prudent to take in approximately

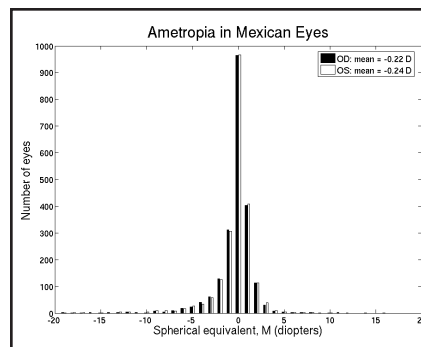


Figure 2. Distribution of sphere equivalent (M) refractive error of 2,200 patients.

8,000 pairs of glasses, which was a factor of three to four times the number of patients being dispensed. In the first few trips the inventory of glasses would be acquired by a combination of glasses provided by I-Care and the students verifying glasses that were donated at IUSO. The data entry step doubled the work required before the campaign. Fortunately we discovered the Lion's Eyeglass and Medical Equipment Recycling Inc. The Lions have a very large operation, currently located in Upland, Indiana. The operations manager is Lion John Clester, assisted by his wife Lion Arlene and their core group of volunteers. The Lions recycle and distribute millions of glasses for all sorts of humanitarian programs all over the world. For the last six years, our system has been to take most donated glasses that arrive at the optometry school to Upland and there acquire our specific inventory that we would need for the upcoming trip. Usually we could bring those spectacles back to Bloomington on the same visit to Upland.

With the discovery of the Lions large recycling operation and learning how their system worked, it became an idea to see if bar coding could be implemented as a way to dramatically reduce the data entry process. In discussions with other volunteer groups providing refractive correction on missions, it had become clear that most groups could not find the workforce to input the numbers before actually traveling to their mission site. Garringer et al. is our report on how successful this could be.⁷ We found that the number of hours could be reduced by a factor of four if bar codes were labeling the bags with the glasses. We also started working with Holland Kendall (Kendall Optometry Ministry, Inc.) who is an electrical engineer by training. Over the course of a couple of years Mr. Kendall has interfaced most autorefractors with small DYMO printers and worked out a twenty six character bar code that carries the information for the fields in the database. The Lions recycling center has experimented with this system but shifting their system to embrace the bar codes has not occurred to much extent because there is little demand but by Mr. Kendall and his associates.

Another challenge was brought to a head by the airlines industry choosing to enforce an obstructive policy of not including boxes as part of our checked luggage. Since 1993 the strategy had been to have all participants agree to limit their luggage to one piece of personal items and one box filled with supplies or glasses. Continental Airlines had threatened many times that they were going to treat the boxes as a stand-by item and delay them from reaching Guanajuato. We had

hoped that our goal of attempting to help people would gain some measure of good will and support, but Continental enforced their threatened limitations about three years ago and delayed the inventory from being available for the campaign by a couple of days. There's nothing like anticipating at least five hundred people hoping for glasses and no inventory to distribute. Several leaders of humanitarian missions around the state have had canvas bags constructed that precisely match the dimensions of the boxes they receive from the Lions to make transportation of the glasses possible within this policy. The reaction to the emergency was to bring to the campaign the stored inventory that had been accumulating in Guanajuato over the last ten years and we discovered there was a very large inventory already there. So for the last couple of campaigns after the experience with Continental, we have been dispensing out of this large inventory and bringing selected prescriptions to supplement specific refractive corrections so the inventory retains adequate numbers in the high volume areas of the lower prescriptions.

One other optics or refractive error related investigation that experience in Mexico has led to is examining how astigmatism might vary as a function of spherical ametropia in different ethnic or racial populations.⁸⁻¹⁰ Power vectors allow you to examine this question without reducing the information to just a comparison of the magnitude of the astigmatism being compared only to the spherical ametropia.

Managing eye disease and training optometry students

So by 1997, the participants of the campaigns had shifted from roughly equal numbers of volunteers from I-Care and IUSO students, faculty and alumni to a group dominated by IU. I-Care logically was shifting their volunteers to serving in other missions in Mexico. By the 1997 trip only five I-Care volunteers were leading the effort and approximately 39 participants were linked to IU. We typically start at the beginning of the fall semester with the idea that we will take approximately 30 students from the first three years of the optometry program, starting with the loose structure that we would like to take five 1st year, ten 2nd year and fifteen 3rd year students. This number is then adjusted by the effort of the interested students with the decision of the participant list in the hands of the leadership of student VOSH. I select the other nine participants from faculty, alumni and fourth year students with concern for specific jobs and supervision needs.

With the database system, we found that

during most of a campaign day, the dispensary could keep up with a staff of around five students and Ms. Gondry. One of the unique educational

experiences is the opportunity to examine large numbers of patients with a variety of diseases, and we found that we were in a position to embrace this opportunity. In 1998 we discussed this unique opportunity in a paper in the *Journal of Optometric Education*.¹¹ As one might expect, the optometry students were fine with helping in the

disease that can be seen. This year's Academy presentation (if accepted) shows that there is dramatically high prevalence of anterior eye disease in the Mexican population we're serving, and a rich experience to be had in examining (in many cases end stage) retinal disease that comes from the rampant diabetes and glaucoma in this poor generally underserved population.

The general scheme for the campaign was that initially DIF's social works would organize transportation for patients needing eye care from around the state. Figure 3 shows a map of the state of Guanajuato. The state is divided into 46 municipalities, and buses from those municipalities were scheduled to arrive on particular days and times to stagger the patient flow. When a bus arrived (Figure 4) the patients are guided to the initial staging area, local volunteers would fill out the exam form for each patient (Figure 5), which included some elements of history and chief complaint. The second station would be distance visual acuity testing. The tests were administered by DIF optometric staff or students from the local nursing program (Figure 6). The third station was autorefractometry usually supervised by one of our doctors or fourth year students but manned by local people (Figure 7). The fourth station was preliminary testing by our second and third year students, with emphasis on checking blood pressure in addition to screening for ocular motor problems (Figure 8). The fourth station was undilated direct ophthalmoscopy by the second and third year students. Then, in the absence of any other issues, the patient's data are reviewed by one of the doctors (Figure 9) and the patient sent to the dispensary when indicated (Figure 10).

If during the screening, additional testing was indicated, then internal referrals were made. The additional testing may include anterior or posterior eye investigations, photo documentation, or additional estimates of refractive error. Each year since 1997, we have added more and more talent and equipment to enhance our ability to examine eye disease. So even though many stations have been made more efficient, they have also been made more comprehensive. The time required to examine around 500 people in one day has stayed about the same because we have added more tests even though in some sense we have become more efficient. Initially young alumni manned the disease station. In 2000, Dr. Vic Malinovsky, Chief of our Disease Service, joined the campaign. Currently he has added participation in this campaign to the accreditation outline of activity for his resident. Numerous presentations of the prevalence of disease in this population have occurred at various professional meetings.¹²⁻¹⁹



Figure 3. State map of Guanajuato showing the administrative structure of DIF and the forty six municipalities.



Figure 4. Patients exiting a bus and assembling on the south side of the new clinic during the VOSH campaign 2007.



Figure 5. Nursing students interviewing patients during the intake and case history step of the 2007 campaign.



Figure 6. Distance visual acuity being administered during the 2007 campaign.

dispensary and a few even preferred that job. But what most students wanted was to see and learn from the wild variety of ocular and systemic

Interesting comparisons between rural and urban patients and the surprising discovery of pseudoexfoliation and the massive problems with pterygium are examples of the presentations.

One of the great concerns as you invest more and more resources and manpower into screening and diagnosing disease is by whom and how will interventions and follow-up care occur. In 1998, I brought a letter from then head of the medical activities of DIF, Dr. Carlos Perez, back to IU. Dr. Perez was introducing the idea to our administration of actually having a full time clinic in Guanajuato. Two factors were also key in giving Dr. Perez's idea serious consideration. First, Dean Jerry Lowther had demonstrated significant interest in international vision care, and we had an alum that was interested in working and living full time in Guanajuato. It was hard for me to imagine putting the project together without having an IUSO employee resident in Guanajuato engaged in the effort.

Dr. Cynthia Foster (class of 1995) had been a consistent volunteer in the VOSH campaign as a student and after graduation. Dr. Foster also had spent the summer after graduation volunteering at the DIF out-patient clinic. Dr. Foster had great interest in serving the Hispanic population and was practicing in Corpus Christi, Texas.

I remember a particularly pivotal week in 1999 when Mr. Guitierrez (of I-Care), Dr. Foster, and I were shown space of approximately 1200 square feet in the Guanajuato General Hospital. We then met with local architects and drew up a modest four lane clinic, with a single office and small reception area and waited to hear the estimate for partitioning up the space. The estimate was just short of 100,000 pesos, which was only around \$10,000. The agreement I brought back to be considered by the administration and faculty was basically that IUSO would pay for the remodel but there would be no lease charge for the space and utilities. It was understood that the instruments and the faculty salary would come from IU. Two staff members would be provided by DIF, which included a receptionist and custodian/handyman. The campaign would still continue each year, because the need would not be addressed completely by a small clinic alone. The clinic provided a solution to the question of where to refer and continuing care.

In late spring of 1999, the faculty voted unanimously to remodel the space and hire faculty to supervise students. After the required search, Dr. Foster was hired. In February of 2000, two fourth year students joined Dr. Foster for the initial opening of our Guanajuato Clinic. It might be interesting for the reader to be aware that the

Governor of Guanajuato for the term from 1994 to 2000 was Vicente Fox, who would leave the Governorship and be elected President of Mexico in 2000. The one time six year term of the Governorship of Guanajuato will actually turn out to be quite a significant issue when it came to continuity in the top administration in DIF and the serious challenges of shipping equipment and supplies to the clinic through Mexican Customs. In fact just as we were starting the clinic we found that all the leaders of DIF were out, which included Dr. Perez.

As time went on and we got to know the new leaders of DIF, an unexpected exciting development was that the wife (who liked to be called Faffie) of Governor Juan Carlos Romero Hicks became president of DIF. Mrs. Romero (Faffie) grew up in Wisconsin. She would prove to be a very energetic leader of DIF with numerous effective programs to help the poor of Guanajuato. After a year or two, we developed a great working relationship. She assisted us in getting supplies and equipment through and set the stage for the next large step in our growth in Mexico.

In the fall of 2004, Dr. Foster stepped down, and Dr. Jennifer Page (class of 2002) assumed the clinic director role. During this period of changing supervisors, I had larger number of visits to Guanajuato. Our new clinic was a solution to referring for optometric care, but we had no solution for the tens of thousands of poor that need surgical interventions. As a rule, cataracts had to be very dense before



Figure 7. The autorefractor step during the 2007 campaign.



Figure 8. Second year optometry student, Roxana De La Rosa, administering cover test during 2007 campaign.



Figure 9. Dr. Ed Schneider reviewing findings during the 2007 campaign.



Figure 10. The dispensary station showing the numerous boxes of glasses. Pictured from left to right opt. tech. graduate Bren Hoover with first year optometry students Jennifer Hill, Rebecca Baxter, Anna Bedwell and Miranda Murray.

the patient would receive care and vitrectomy (so important with care for the diabetic) was simply not available. During a meeting with Faffie and her staff at DIF, I asked them to work up an estimate of the costs for a facility containing optometric and surgical areas.

The result of this estimate was that it would take around 2.5 million pesos or around \$250,000. The idea required a large space where both optometric and surgical treatments might occur. This was attractive for two reasons. We would be enriching the experience of our students, as well as, positioning us to assist as we could in expanding surgical options. Perhaps the day might come for surgical campaigns to begin and improvements in the technical aspects of the surgeries provided by the ophthalmologists on DIF's staff. Surprisingly, about six months later when I visited again, Dr. Page and I sat through a presentation by the medical leaders of DIF that they wanted to build a large vision care clinic with all the eye care provided by DIF and IUSO under one roof.

Construction of the new clinic began in the fall of 2005, and significant progress had been made by the March campaign of 2006. The funding of the clinic had come solely through the Mexican Federal Government and the State of Guanajuato. I believe Faffie had many other successes in raising private funds, but we really don't know many of those details. It is my understanding that the price of the new clinic was around 10 million pesos or \$1,000,000. A grand opening that Dean Lowther and Clinic Director Steve Hitzeman and I attended was held on July 4, 2006. At that time, the equipment, files, and supplies were all moved out of the Guanajuato Hospital and into the new clinic "Centro de Rehabilitacion Visual." Several benefits become obvious to us. First, all the eye care sponsored by DIF was now under one roof, thus dramatically improving communication between the other eye care providers and us and providing the opportunity to influence the standard of care. Secondly, the social workers in their role of arranging transportation would sometimes make medically unsound or perhaps inconsistent decisions on the person to whom they sent their client. With all care in one building the patients were much more likely to get triaged appropriately. The third great benefit was that we could, with this facility, have operating rooms and see a future where there might be a lot more ocular surgeries.

We have received great help from Advanced Medical Optics and consultations from Dr. Kevin Waltz. Several phacoemulsifiers and numerous supplies have been donated by AMO. Dr. Waltz

plans to supervise installation and training and to mount surgical campaigns once the equipment and supplies reach the clinic. We are somewhat stalled on this issue because last summer was the 2006 election and the new governor has appointed all new leadership in DIF. Our initial contact with the new state government has been very good so far, and we are hoping that the new DIF staff will facilitate the appropriate documentation for bringing in the surgical equipment.

Other successes and acknowledgements

IUSO has also been willing to manufacture spectacles for children and some adults with strong prescriptions since the clinic opened in 2000. For several years, most patients were given prescriptions and went to optical shops in the area. However, the shipment of equipment that was sent in 1999 to furnish the lanes and offices also included edging equipment and significant stock of finished lenses. One of the additional accomplishments that we realized as Dr. Page took over was the start of a manufacturing lab. We have received a very large donation of lenses (and some financial support for VOSH) from Essilor and significant donations of frames from Ocean Optical, Spectara, Indiana VOSH, and the Lions. An injection mold system from Opticast, which would allow us to make bifocal, progressive, and aspheric lens designs, was also shipped to the new clinic. The lab in Bloomington does continue to supply some prescriptions and for the poorest patients, recycled glasses are sometime dispensed (or dispensed temporarily).

Another recent change in our campaign has been to add extra personnel (i.e., five more people) with the role of examining children. In our normal campaign for adults, we felt did a pretty good job of solving problems and referring appropriately, acknowledging the limited choices in some cases. However with children, we found our system really only was an elaborate screening, and we were not comfortable with the treatment options that were available. We knew from our experiences that most adults we were seeing had problems that needed to be addressed (a high percentage of true positives). We had some concern whether we would end up examining a lot of children with only school screening like percentages (i.e., 10 to 15% true positives). We tried the additional children's program in the 2006 campaign and we found that at least 85% of the children were in need of significant eye care.

To close this history, I would like to mention a few other consistent contributors to this effort. I would first like to invite the reader to review the list

of references and see that nearly 40 people are listed and contributed directly to this effort as important and persistent volunteers. In addition, I would like to acknowledge Drs. Pete and Elli Kollbaum who have participated in many campaigns and have been responsible for getting donations of a large amount of pharmaceuticals for both the campaign and the clinic each year, and Drs. Ed Schneider and Jeff Perotti for replacing me at the assessment (check-out) desk and probably improving the standard of care substantially. I would also like to acknowledge Dr. Neel Vyas and Dr. Val Sharpe, both of whom have participated nearly every campaign since their graduations in 1998 and 2001, respectively.

The future has great prospects. We should hope to see the surgical improvements before the year is out. We have had a significant amount of low vision aids donated and Blanchard Contact Lens, Inc. is helping us find solution for all the keratoconic patients we are seeing. The new clinic has some network capability that we will grow. With the imaging emphasis of many of our faculty, we anticipate testing advancements in telemedicine. And the most recent development is that Dean Lowther has found the money to hire a resident for Guanajuato. The resident should lead to more students, possibly even those trained in Mexico and provide the ability to serve more patients. As the classic song by Timbuk3 goes: "The futures so bright, I gotta wear shades".

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