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TECHNICAL REPORT

Cataract Blindness and Simulation-Based Training for Cataract Surgeons

An Assessment of the HelpMeSee Approach

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Summary

Introduction

Cataract accounts for about half of all cases of blindness worldwide, with an estimated 20 million people suffering from bilateral cataracts (World Health Organization website, undated). The overwhelming majority of these cases are in developing countries, where blindness and visual impairment (VI) can have enormous negative impacts on the quality of life, along with reducing life expectancy and economic productivity. Yet the great majority of cases of cataract VI can be cured by quick and inexpensive surgical procedures, with very high success rates in developing country contexts. Manual Small Incision Cataract Surgery (MSICS) is a safe, low-cost, and very rapid surgical method for cataract removal that has been shown to have success rates equivalent to more complex and costly methods.

Significant strides have been made in certain regions or countries in providing high-volume, low-cost, and high-quality cataract surgery. However, an acute shortage of trained cataract surgeons makes it unlikely that the need for such surgeries—estimated to reach 32 million cases globally by 2020—can be met under current practices. Uptake of surgery has also been constrained by cost, lack of geographical access (due to both an inadequate number of surgeons and the fact that those who can perform the procedure tend to practice in large urban centers), and low quality of outcomes in many contexts, which inhibits demand.

To address this problem, HelpMeSee, Inc. (HMS) is developing an innovative approach to cataract surgery training and delivery. The HMS approach includes the following:

- The use of high-fidelity simulator technology and associated course curricula for high-volume training in MSICS. Simulators have the potential to dramatically speed up surgical training as they reduce the need for actual patients and eliminate the risks of training on real eyes. HMS plans to open an initial regional learning (training) center as early as 2013 and three to five more centers within several years after that. The centers will be set up in Asia, Africa, and Latin America, and each is expected to have the capacity to train up to 1,000 MSICS surgeon candidates per year from countries across these regions.
- The development of an HMS-supported system of independent private MSICS practitioners, a contrast to traditional highly centralized, hospital-based systems. Practitioners will be part of a supply provision and oversight network administered by HMS. HMS will reimburse surgeons on a fee-for-service basis; hence they will be incentivized to seek out treatable cataract cases in the areas they serve. The objective is to select trainees who, in addition to having appropriate backgrounds and potential, will be willing to live and

work in underserved areas. Monitoring of quality of outcomes as well as documentation for reimbursements will rely primarily on photographic and other electronic documentation transmitted via Internet (or other means as needed) to HMS.

- Because of limits on the supply of ophthalmologists and medical doctors willing or able to perform cataract surgeries, the HMS training in MSICS will not be limited to medical doctors, although they are still predicted to make up perhaps 60 percent of the trainees globally. It will extend to other medical professionals as well as individuals without medical training as is necessary to meet the needs of local populations for qualified cataract surgeons.

This study assesses the potential of the HMS approach to significantly reduce the problem of cataract-caused blindness and low vision in the developing world. Specifically, the analysis develops a model to forecast the prevalence of cataract-caused vision impairment in Africa, Asia, and Latin America under "status quo" and several "HMS" scenarios to estimate the potential effects on the prevalence of cataract-caused VI, Disability Adjusted Life Years (DALYs), and economic losses. We assess the potential cost-effectiveness of the HMS approach (dollar cost per DALY averted). We also consider a range of potential challenges to the success of the HMS model, and discuss how a pilot study can assess some of these factors.

Existing Successful Models of Cataract Surgery Training and Delivery

A review of the main characteristics of existing successful cataract surgery systems in developing countries helps to put the HMS approach in broader perspective. We considered Aravind in India, Tilganga in Nepal, and Project Vision and He Hospitals, both in China, as well as several examples from Africa. Successful systems are marked by high quality of surgical outcomes, highly effective management and quality control, and a very high degree of specialization and standardization of tasks that applies to cataract surgeons, nurses, and other staff, including managers. Specialization and the efficiencies it brings make it possible to carry out a high volume of surgeries, which helps to build up and maintain surgeons' skills. High volume and efficient management allow for very low unit costs per surgery. High *quality* builds up the credibility of the program and thus further encourages greater uptake.

In addition to building a reputation for high-quality outcomes, high uptake in these examples is achieved through aggressive outreach and screening, To avoid inconvenience and excess transportation burdens on poor rural clients, surgery typically follows very soon or immediately after screening, usually via transportation to base hospitals or in some cases (as in Nepal) using surgical camps in rural areas. This way, patients do not have to travel long distances for a cataract diagnosis that will tell them if they can be treated. Further, other eye conditions are also diagnosed and treated in most approaches, not just cataracts.

Main Findings of the Forecasting Modeling

The model predicts that under the "status quo"—meaning that the current share of those in need who receive cataract surgery is constant into the future—the numbers of visually impaired (blind or with low vision) individuals needing cataract surgery will grow to huge pro-

portions in the coming decades. This reflects population growth as well as population aging, since cataracts are highly age-related. For example, the number of cases of cataract-caused VI in the Southeast Asia region (SEAR), which includes India, will be more than 32 million by 2012 and will rise to a staggering 53 million cases by 2030. For cataract-caused blindness specifically (as opposed to all VI), this corresponds to 8 million cases in 2012 and 14 million cases by 2030.

In the Western Pacific region (WPR), which includes China, the percentage prevalence is lower than in SEAR, as well as in the Africa region (AFR). Still, in absolute numbers, WPR contributes an enormous number of cases of cataract-caused VI (26 million in 2012) and blindness (6 million in 2012). By 2030, under the status quo, these numbers climb to 40 million and 9 million cases, respectively. Africa has 19 million cases of cataract-caused VI in 2012 and 5 million cases of cataract-caused blindness. Due to relatively rapid population growth, these numbers climb sharply over time to 32 million VI and 8 million blindness cases by 2030, even though prevalence rates increase only modestly in the region. In contrast, both nominal and percentage prevalence is forecasted to remain relatively low in the America 2 region (AMR 2), which includes Latin America.

Modeling the Potential Impacts of HMS

We used HMS's assumptions about costs and training capacity, and it is important to note that the results reflect these assumptions. We assume in our main simulations that resources are available to train a planned 30,000 new surgeons. We explored the impacts under different assumptions about uptake of HMS surgeries: low (20 percent of cataract-caused VI individuals not operated on elsewhere are operated on by HMS); medium (50 percent operated on by HMS); and high (80 percent operated on by HMS). The model predicts the impacts on cataract-caused blindness and low vision as a function of prevalence, demand or uptake, and the growth of the supply of surgeons. Under these assumptions, we find that:

- The HMS program will have the ability to scale up cataract surgical capacity very rapidly, reflecting the speed with which the simulator training produces new surgeons. Once this large supply of surgeons has been built up, the effects on VI prevalence will be determined mainly by the level of demand or uptake. Under very optimistic assumptions (80 percent), HMS can largely close the backlog of surgical cases in the four major regions studied, resulting in 21 million cases of cataract-caused VI in 2030 (including 5 million cataract-caused blindness cases) compared with 134 million cases (including 26 million blind) under the status quo. With medium uptake (50 percent), HMS can substantially reduce prevalence, by 82 million cataract-caused VI cases (13 million blind) relative to the status quo in 2030. Under low uptake (20 percent), impacts on prevalence are correspondingly modest.
- By reducing cataract-caused VI, the program potentially will have significant impacts in the future on DALYs and economic output. The latter outcome reflects the large expected losses to national income of cataract-caused VI under the status quo. SEAR sees the most dramatic reductions in prevalence under HMS, leading to a large benefit to gross domestic product (GDP) under high-uptake scenarios: for the 80 percent uptake scenario, the difference from the status quo in 2030 is about 0.6 of a percent of GDP for that year, or

in U.S. dollars (US$), about US$18 billion. For WPR 2, the proportional gains to GDP are similar, reflecting high employment rates, but the absolute or dollar gains are much larger given the economic size of this region: GDP would be US$52 billion higher in 2030. For AFR, the percentage gains by 2030 are also more than half a percent of GDP (US$9 billion) for the 80 percent uptake scenario.

However, the model also suggests the potential for a significant oversupply of surgical capacity (and surgeons) once the cataract surgery backlog is eliminated or reduced as much as it can be given uptake rates. When this occurs depends on regional variation in prevalence as well as assumptions about uptake; it will happen later if uptake is high, since there will be more back cases to operate on. For 50 percent uptake, this point is reached in 2021 in AFR (i.e., after eight years), 2024 in SEAR, 2023 in WPR (excluding developed nations), and 2017 in AMR 2. After that point, practitioners must rely solely on new cases of cataract-caused VI, or increased demand from those with less advanced cataracts. With regard to the latter, in the United States and other rich countries, where populations are also well insured, there is a very robust demand for cataract surgery from individuals who are mostly well below the World Health Organization (WHO) threshold for low vision. In poorer countries, the subjective threshold for desiring (and being willing to pay for) surgery is currently significantly higher. This may change as cataract surgery becomes more common and incomes rise. However, the prospects for this are uncertain, so there remains a possibility that the rapid scale-up of MSICS surgical capacity will eventually lead to redundancies among MSICS specialists. This will pose a problem for practitioners who do not have broader ophthalmological training in other, non-surgical areas of vision care. However, in some contexts even these specialists may be able to successfully adapt by turning to the provision of care for minor eye conditions, performing more referral functions for larger care organizations, or providing optometry services. The possibilities for these adaptations will depend heavily on the local licensing environment with respect to these services.

Costs and Cost-Effectiveness

Reducing costs per surgery through efficient management and high surgical volume is a key objective for cataract surgery systems. Given fixed costs of the learning centers and individual practices, unit costs for HMS depend on the number of operations each surgeon performs per year, which in turn depends on prevalence, the total supply of surgeons, and uptake rates. The model estimates for costs per surgery vary by region and year. For the year 2017 and 50 percent uptake, they range in international dollars (I$)from I$69 in SEAR to I$138 in AMR 2 (international dollars adjust for price differences across countries). These estimates are generally higher than other unit cost estimates for MSICS in the literature, but they include all program costs as well as costs of surgical training, not just the practitioner costs. The SEAR costs are broadly comparable to, although lower than, those for Aravind's Coimbatore hospital in Tamil Nadu, India. However, for later years, once the backlog of cases is cleared, per-surgery costs in the HMS system rise sharply, because the number of operations per surgeon falls.

Cost-effectiveness measures the cost in dollars of gaining an additional year of healthy life from an intervention. This is equivalent to averting one DALY. Under the assumptions about HMS's expansion of surgical capacity, the program can have very large impacts on DALYs:

Over the ten-year period from 2014 to 2023, for uptake of 50 percent, about 15 million DALYs would be averted in AFR, 18 million in SEAR, 16 million in WPR (excluding developed countries), and 7 million in AMR 2. Cost-effectiveness ratios, or the cost per DALY averted, range from I$114 in SEAR to I$515 in AMR 2, again assuming 50 percent uptake and a ten-year period. This is well under the per capita GDP of these regions, and the same holds for the other two regions. By this benchmark, the HMS program could be very cost-effective. In later years, however, this conclusion may not hold as costs per surgery rise due to falls in demand as the surgery backlog is closed or reduced.

Potential Challenges

While the use of simulator training and other aspects of the HMS model have the potential to make a significant impact on the prevalence of cataract-caused blindness and low vision in developing countries, there are also potential challenges to achieving this goal. One, already noted, is the potential for oversupply of surgeons in later years. The report identifies several other possible obstacles, based on the literature and extensive discussions with experts.

- Several aspects of the service delivery approach may pose challenges to the HMS model. Ensuring that outreach and screening efforts are adequate to bring large numbers of patients to individual practitioners is a key issue. While HMS is planning to conduct education outreach campaigns, at present it appears that arranging for the screening of individuals for operable cataracts will be the responsibility of the practitioner. This and other aspects of managing the practice may impose a significant burden on practitioners who are expected to perform high-volume surgery at the same time. In most successful cataract systems, all management as well as screening functions are out of the hands of the surgeons.
- In a number of other cataract care systems, efforts are made to ensure that patients do not have to travel far just to learn if they are operable, since having to do so is a disincentive to uptake. Instead, they only must get to local screenings. Transportation to surgery is often provided at or after the screening for patients diagnosed with operable cataracts. Unless HMS practitioners can organize local screenings by qualified medical staff, individuals with poor vision may be reluctant to travel to the practitioner's office, since they do not know if there will be a benefit. This will be offset to the extent that the distribution of independent MSICS practitioners makes them more locally accessible to rural populations, which will encourage visits. However, even independent practitioners will generally need to be centrally located in towns.
- HMS practitioners will be trained only to perform MSICS. This has benefits from the point of view of the gains in proficiency from specialization, as shown by existing successful cataract surgery systems. However, unlike other systems, treatment will not be provided for other eye conditions, so all such cases will have to be referred. This may create a situation where a significant share of clients are disappointed, with negative reputational and demand impacts, even though the HMS practitioners are appropriately refraining from treating conditions beyond their training. Whether this is a problem in practice depends on who comes to the HMS practitioner. "Disappointment" may occur frequently if people travel to the practitioner for a broad variety of eye problems such as infections,

which the HMS practitioner cannot treat. Marketing strategies need to be designed to ensure, to the extent possible, the appropriate kind of demand, i.e., from visually impaired individuals. This will narrow the pool of patients to those who may potentially be helped by the HMS practitioner. Still, some visually impaired patients—for example, those with glaucoma whose vision loss could be halted with appropriate treatment—will be told they must travel to a medical doctor or other facility for care.

- Monitoring of performance is much harder under a system of geographically dispersed independent practitioners than in, say, a hospital context. An effective system of surgical outcomes monitoring is essential if practitioners are to be incentivized to maintain the quality as well as the quantity of surgeries. Apart from incentives, oversight is especially important for the many HMS surgeons who will not be trained doctors or even medical professionals. HMS fully recognizes the need for strong oversight and is developing a technology-driven approach to this issue, relying on sophisticated imaging and other forms of verification. Some of these approaches are in use in other medical contexts (e.g., with SmileTrain), but they have yet to be tested for remote monitoring of cataract surgeon performance. Also untested are the systems for supplying dispersed local practitioners with lenses and other essential surgical items.

Benefits of a Pilot Study

Given the innovative nature of many aspects of the HMS approach, piloting is very important. HMS recognizes this and is planning a pilot involving 100 trainees, about 80 percent of whom would be licensed ophthalmologists with little or no surgical experience, with the remainder being MSICS surgeons who would enhance their skills to increase the quality and volume of surgeries they can perform. The objective of the pilot will be to assess the effectiveness of the simulator and courseware training approach. This pedagogical assessment is clearly the first order of business of an evaluation of the HMS system. The pilot will not assess other aspects of the HMS model, such as the monitoring and quality control system, supplies procurement, payment systems, and outreach. Thus, the pilot as planned will play an essential but limited role. The other aspects of the approach just described also need to be carefully assessed, since many of these are new, including the sophisticated remote monitoring of outcomes and the reliance on independent MSICS practitioners. Careful, ongoing monitoring will be essential, with adjustments to the approach made as needed. Starting with one regional center and carefully monitoring outcomes over a period of several years, rather than creating four to six such centers at one time, is highly advisable.

Another limitation of the pilot as currently planned is the limitation of trainees for the assessment to those who are practicing ophthalmologists; a minority will even be MSICS surgeons. It is logical to first pilot on relatively skilled individuals and then shift the focus to nondoctors (and nonmedical professionals), who will be more challenging to train. It would be advisable to follow the initial pilot with a similar evaluation of the teaching approach on an equivalently sized cohort of nondoctors and nonmedical professionals. This would establish the effectiveness of the training model for this group, or point to areas for improvement. This should be done before considering going to scale in the training of nondoctors.

Finally, the simulator may have significant benefits as a training tool for other cataract systems which otherwise share relatively little in common with HMS; for example, the cen-

tralized systems of training and delivery such as Aravind and Tilganga. The simulator as a training tool is separable from the other key components of the HMS approach—that is, the private-practice model and use of individuals who are not ophthalmologists. If the HMS pilot study demonstrates the pedagogical effectiveness of the simulator, it would be worth exploring whether the simulator technology can increase training output and efficacy in more standard cataract surgery systems as well.