International Perspectives: Models of Technology Transfer to Developing Countries: Experience of Three Decades
Dharmapuri Vidyasagar

NeoReviews 2009;10:e1-e9
DOI: 10.1542/neo.10-1-e1

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://neoreviews.aappublications.org/cgi/content/full/neoreviews;10/1/e1
Models of Technology Transfer to Developing Countries: Experience of Three Decades

Dharmapuri Vidyasagar, MD*

Abstract
Transfer of technology from developed to developing countries can improve health care worldwide. Several approaches have been used with varying success, including self-sponsored models, government- or institution-sponsored models, planned program development, and single or multinational/multi-institutional collaboration. Although technology transfer and training of individuals are highly important, sustainable programs may provide the most lasting effects. Successful partnerships require fiscal commitments, cooperation, strategic planning, and thoughtful human interrelationships.

Introduction
Scientific progress during the 20th century was responsible for reduced overall mortality rates, increased life expectancy, and decreased infant mortality rates. However, such progress has not been even across the globe. While developed countries enjoy better health, developing countries suffer. For example, the infant mortality rate (IMR) in developed countries is as low as less than 10/1,000 compared with a range of 100/1,000 and greater in developing countries. IMR in developed countries has dropped dramatically during the last quarter of the last century; not so in the developing countries. It is estimated that as many as 50% of such infant deaths could be prevented through simple interventions. (1)

The major barriers to prevention of high IMR in developing countries are lack of skilled personnel and lack of equipment at every level of the health-care system. For example, in rural areas, a skilled attendant, known to decrease neonatal mortality drastically at births, seldom is present. In addition, the workforce gap between developing and developed countries is a major barrier to progress in health-care delivery. (2) Shortages of skilled physicians, nurses, and technicians are seen at institutional and hospital levels in most developing countries. (3) Hence, there is an urgent need for capacity building. On a global scale, this task requires involvement of multiple systems.

Although there is a dire need for training skilled personnel in developing countries and a great interest on the part of professionals in developed countries to offer their services, no single accepted program model has been shown to produce optimal results. Each interested individual or institution has to choose the appropriate models to fit their fiscal and administrative support. The primary objectives of the program should include: 1) capacity building, 2) providing necessary equipment, and

Abbreviations
AIHA: American International Health Alliance
IMR: infant mortality rate
JNMC: JN Medical College
LRC: learning resource center
MOH: Ministry of Health
NICU: neonatal intensive care unit
NIS: Newly Independent States
NRP: Neonatal Resuscitation Program
TASHMI: Tashkent Medical Institute
UIC: University of Illinois at Chicago

*Professor of Pediatrics (Emeritus), Department of Pediatrics, University of Illinois at Chicago, Chicago, Ill.; Department of International Health, School of Public Health, Johns Hopkins University, Baltimore, Md.
developing a sustainable program. “Capacity building” refers to enhancing the skills of caregivers (physicians, nurses, and other health workers). “Technology transfer” refers to providing new skills and tools to carry out procedures, such as equipment used in neonatal resuscitation, incubators, and ventilatory support devices.

This article describes various models that have been in use for transfer of technology to developing countries as well as personal experiences in this area over the past 25 years. Finally, guidelines are offered for developing successful programs.

Program Models
Transfer of knowledge from one country to another is accomplished through many pathways. Figure 1 depicts various models used for transfer of technology. Each has advantages and disadvantages.

Training of Individual Professionals
In this commonly used model, an individual professional from a developing country acquires knowledge and skills by enrolling in a training program in a developed country. The expectation is for this individual to return to his or her own country and embark on programs that enable him or her to train many other professionals. The training program could be self-sponsored by the individual or supported by a government or institution. This model has several limiting factors. In a self-sponsored program, the individual has no obligation to return to the country of origin. Thus, the program lacks a national impact value. An individual sponsored by an institution or the government has a greater potential to affect larger groups of health-care workers and, thus, has a larger impact value. It casts a larger “knowledge footprint” among colleagues. The impact value, however, depends on the efficiency of the system in using the newly acquired knowledge and skills of the individual. Private institutions are likely to gain more from this model than government-sponsored programs because of other barriers in the government system.

Among the other drawbacks in self-sponsored programs is that very few health-care professionals return to their home countries after gaining advanced training in a developed country. The primary reasons for not returning to the home country include: lack of opportunity for employment, lack of appropriate use of skills, and lack of a support system to practice. Usually such individuals remain in the adopted countries, adding to the loss of skilled professionals in developing countries. The loss of large numbers of professionals results in a “brain drain,” which can jeopar-
dize the country of origin. This is a widespread phenomenon in many developing countries, particularly in Africa. (4)

A better strategy is for the government to embark on a specific program in an area of need and to train a senior professional in a leadership position in program development, who would be able to implement the strategic plan successfully upon completion of training abroad.

**Planned Program Development**

Planned program development may be initiated by a government agency, a national or international organization, an institution, or a professional organization. Planned programs usually focus on developing a specific program in an institution or across the country. A selected professional is sponsored for training in a developed country, with a clear plan for placement of the professional upon return. This model has the potential of broader impact on the society. However, 2 to 3 years or longer may be required to obtain the desired results in the best of circumstances. Private organizations are more efficient in implementing such programs than government agencies. This model is very cost effective, with a potentially large impact on the society.

**Institution-to-institution Collaboration**

This relatively new phenomenon started to evolve in the latter part of the 20th century. The concept is that an institution from a developed country links with an institution that has similar interest in a developing country, with the primary objective of improving multiple disciplines in the collaborating institution through capacity building and transfer of technology. Because such programs often are initiated and supported by the administration, usually the Ministry of Health (MOH), in the developing country, the prospects of success are greater. Further, because such programs involve multiple disciplines within the institution or the country, it casts a much larger “knowledge footprint.” Several examples of success are described later in this article.

**MULTI-INSTITUTIONAL AND MULTI-NATIONAL PROGRAMS.** In this model, an agency or a foundation in a developed country facilitates the cooperation of several institutions in a developing country to establish partnerships with their counterparts in different institutions in multiple developing countries. The intent is to accelerate diffusion of technology and knowledge simultaneously across a larger population. This model leaves an even larger “knowledge footprint” across wide regions in a short period. A successful program was modeled and implemented on this concept by the American International Health Alliance (AIHA) based in Washington, DC.

In 1992, following the breakup of the Soviet Union, the Newly Independent States (NIS) had a seriously disrupted health-care system that was affecting the health of their people adversely. The life expectancy dropped precipitously, and the IMR increased. As the relationship between the United States and NIS countries began to improve, a unique program was initiated through the United States Agency for International Development to improve health conditions in NIS countries. The program was managed by AIHA (USAID grant EE-A-00-98-00010-00). (5)

The organization helped to develop partnership programs between health-care institutions in the United States and health-care institutions in NIS countries. The initial participating NIS countries in 1998 included: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. The University of Illinois at Chicago

---

**Table 1. Summary of American International Health Alliance (AIHA)-sponsored Institutional Partnership Program in Newly Independent States Countries**

<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>● Number of partnerships/programs: 25</td>
</tr>
<tr>
<td>● United States cities involved: 13</td>
</tr>
<tr>
<td>● Central Asian cities involved: 15</td>
</tr>
<tr>
<td>● United States partner institutions: 48</td>
</tr>
<tr>
<td>● Central Asian institutions: 43</td>
</tr>
<tr>
<td>● United States partner person trips: 372</td>
</tr>
<tr>
<td>● Central Asian person trips to United States institutions: 448</td>
</tr>
<tr>
<td>● Total person trips: 834</td>
</tr>
</tbody>
</table>

**Total Number of Health Professionals Trained (37,484)**

| ● United States Agency for International Development funding: $18,699,998 |
| ● Value of in-kind partner contribution: $13,886,401 |
| ● Total cost of the program: $32,586,399 |

Data from American International Health Alliance. (6)
(UIC) developed a partnership with Tashkent Medical Institute II (TASHMI II) in Tashkent, Uzbekistan. The objective was to address various health-care priorities, including women’s health and neonatal issues, faced by the NIS countries at that time. By 2002, AIHA developed 25 partnership programs between the United States and the NIS countries. AIHA later expanded the program to Russia and several other eastern European countries. Table 1 shows the cumulative impact of the AIHA twinning program between United States/NIS hospitals from 1992 through 2006.

The development of partnership programs consisted of several steps. After consultation with respective ministries of health in the respective NIS countries, AIHA identified the needs of the country for delivering health care. AIHA invited United States-based institutions interested in developing partnerships with the institution in NIS countries. A memorandum of understanding was developed and signed by both partners. The program was managed, directed, and financed partly by AIHA. AIHA provided funds for travel for bilateral faculty exchange and the cost of institutional development in the host country; the partner institutions in developed 25 partnership programs at that time. By 2002, AIHA and financed partly by AIHA. AIHA.

The development of partnership programs consisted of several steps. After consultation with respective ministries of health in the respective NIS countries, AIHA identified the needs of the country for delivering health care. AIHA invited United States-based institutions interested in developing partnerships with the institution in NIS countries. A memorandum of understanding was developed and signed by both partners. The program was managed, directed, and financed partly by AIHA. AIHA provided funds for travel for bilateral faculty exchange and the cost of institutional development in the host country; the partner institutions in the United States provided in-kind contributions to the program. This included free professional time, equipment, and sometimes grants. This unique twinning program is truly one of the greatest success stories of transfer of technology from a single developed country to multiple developing countries in a short period of time.

Sustainability
Critical to the success of any program is sustainability. Unfortunately, too often program effectiveness regresses after the closing of collaborations because of lack of administrative commitment. The ingredients of success include strong commitment to the program at the highest level of authority in the host country, whether it is the MOH at the national level or the head of the institution at an institutional level. The host country should develop a strong infrastructure with appropriate commitment of budget to continue the program after completion of the partnership program. It is important to identify a strong leader in the host country/institution who can implement and sustain the program after closing of the collaboration. The success also depends very much on the commitment of stakeholders on both sides of the program. To maintain sustainability, the AIHA twinning program:

- Developed a core group of skilled leaders in each chosen discipline
- Improved local facilities
- Gained commitment of each government to sustain the developed program
- Established several Learning Resource Centers (LRCs) in each of the republics

The LRCs enabled health professionals in the NIS countries to maintain their newly acquired skills and knowledge through connectivity with the professional world. Each LRC is managed by specially trained local staff who are responsible for providing training, outreach, and information support to personnel, patients, and members of the local community. LRC staff also are responsible for working with healthcare professionals at their institutions to conduct periodic literature reviews to facilitate the evaluation of current standards of practice relating to clinical diagnosis, treatment, and prevention. AIHA has established 140 LRCs throughout the former Soviet Union and eastern Europe. Today, the LRCs collectively provide services to a community of more than 70,000 medical professionals across the former Soviet Union and Eastern Europe. The LRCs facilitated:

- Increased access to current health and medical information on a continuous basis
- The adoption of evidence-based practice
- The ability of partner institutions to sustain and access knowledge resources
- The use of information and communication technology tools in creating databases, local area networks, telemedicine, and Web sites

UIC Experience in Developing Countries
It has been our mission over the past 3 decades to facilitate transfer of knowledge, skill, and technology to institutions in developing countries around the world. We used all of the previously described models to accomplish this mission. Our experience involves several countries across the globe. We welcomed individual visiting faculty in leadership positions from different countries to spend various lengths of observation in our neonatal unit. This opportunity enabled them to gain insight into clinical practices and management and organizational skills. We also organized visits of groups of health professionals to India (1971), China (1983), and Poland and Lithuania (1989) to conduct continuing education programs and workshops in various institutions. Following that vast experience, we embarked on the development of institution-to-institution collaborative programs.

China
Our experience in China was facilitated through the World Health Organization in 1983. This was one of
the first neonatal programs initiated by China to link with institutions in the United States. The author had the opportunity to conduct week-long lectures in neonatology and conduct workshops on umbilical vascular catheterization and neonatal ventilation for a group of Chinese neonatologists at China Medical College in Shenyang. Several bilateral exchanges of faculty and nursing staff ensued, resulting in capacity building of faculty and nurses. Dr Wei Ke Lun, the first visiting professor from Shenyang, is the current president of the Chinese Neonatal Society (Fig. 2).

**Indo–United States Faculty (Bilateral) Exchange Program**

This program, initiated at UIC in 1987, (7) included participation by faculty from other institutions in the United States. An informal relationship was developed with the National Neonatal Forum of India, which facilitated selection of faculty from various institutions to participate in the exchange program. Although academic leaders across India already were engaged in developing neonatal intensive care units (NICUs), the purpose of this program was to add impetus to capacity building of physicians and nurses in modern neonatology, including neonatal resuscitation, ventilator care, and prenatal services.

Further, it was recognized that achieving a larger impact in a shorter period of time required a program to train leaders (“train the trainer”) from different institutions in all states of India. The goal was to choose at least one senior faculty member in a leadership position from each of 30 states of the country. The process was accomplished through mutual consensus of National Neonatal Forum leadership and the UIC program coordinator. The NICU at UIC was the site of training in the United States. The faculty exchange was bilateral. The program consisted of visits by a group of Indian faculty to the United States for leadership training and on-site educational programs in selected institutions in India by visiting United States faculty teams. The leadership training program in the United States lasted 6 weeks. Over the period 1987 to 1993, more than 60 faculty members from 20 institutions in India availed themselves of the leadership training.
program. On their return to India, more than 80% of them pursued their careers as neonatologists and contributed to the growth of improved neonatal care in India over the past 2 decades. In addition, these collaborative relationships with the National Neonatal Forum resulted in early introduction in 1989 of the then newly introduced Neonatal Resuscitation Program (NRP) from the United States. (8) The NRP program was well adopted by the National Neonatal Forum and through its efforts trained thousands of health professionals in the country (Fig. 3). The success of the program was the culmination of efforts of numerous dedicated United States neonatologists and highly spirited collaboration of counterparts in India. This train the trainer model serves as an example of successful technology transfer from developed to developing country.

Clinicians at UIC also developed an institution-to-institution collaboration between UIC and JN Medical College (JNMC) in Belgaum, India. JNMC is operated by a nonprofit regional community organization and educational society. The memorandum of understanding between the two institutions was aimed at capacity building and program development at JNMC, not only of faculty in neonatal-perinatal medicine, but also of other disciplines. The host institution supported this program by funding bilateral faculty travel and other expenses; UIC complemented their support with in-kind professional time both in the United States and India. The collaboration program has been highly successful, with a major impact on institutional building in India. Through the joint efforts of UIC and JNMC, JNMC was able to secure a National Institutes of Health-supported Global Network Grant (currently, JNMC/University of Kansas Program). Similarly, UIC/JNMC collaboration resulted in grants funded by March of Dimes New York USA. The success of the program is attributed to the local visionary leadership of JNMC (President Dr Kore and the Dean of the college).

Experience in Poland and Lithuania

Our experiences in Poland and Lithuania are unique in that the programs were initiated by interested parties in their countries. The Polish initiative was taken by Prof. Janusz Gadzinowski, then Rector of Poznan Medical Academy. A memorandum of understanding between UIC and the Academy led to intense bilateral exchange of faculties in neonatology and perinatology during 1989 to 1998. The program was supported through funding by the local Polish community and The Polish National Congress, Chicago, Illinois. The Lithuanian/UIC collaboration was facilitated by a local Lithuania organization, Mercy Lift Lithuania in Chicago, Illinois, and the MOH of Lithuania.

UIC/Uzbekistan Program

As stated previously, UIC was one of the first institutions to enter into a memorandum of understanding with TASHMI II in Tashkent, Uzbekistan, through AIHA. The partnership program placed greatest emphasis on evidence-based medicine, maternal and child health services, and primary care. The program lasted from 1992 to 2002 and facilitated several bilateral exchanges of neonatologists, nurses, anesthesiologists, and hospital administrators between the two institutions. Initial visits were for needs assessment at TASHMI II and choosing the personnel for training and were followed by bilateral exchanges of professionals. AIHA provided the cost of development facilities at TASHMI II and travel costs for their faculty. UIC was funded for faculty travel and administrative cost only. UIC provided in-kind support in the form of faculty time and equipment. Even though the partnership focused on development of a perinatal program at TASHMI II, it also facilitated bilateral exchange of faculty in neonatology, nursing, and other disciplines (neurosurgery and hospital administration). The UIC faculty worked on site in the host country along with their counterparts over an extended period. Overall, there were 44 bilateral faculty trips between the institutions. The TASHMI II faculty spent 634 person days at UIC, and UIC faculty spent 458 days on site at TASHMI II during the period of collaboration. These arrangements resulted in training a core group of leaders and caregivers at TASHMI II and implementation of new programs in each discipline that improved the patient care services and hospital management (Fig. 4).

UIC also initiated the first programmatic activity related to neonatal resuscitation in Central Asia in 1995 through the partnership. AIHA equipped a new NICU within the Tashkent Children Hospital. The unit was staffed with physicians who had participated in a 2-month intensive training session at UIC. In addition to operating the NICU, the Uzbek trainees subsequently instituted their own training sessions at TASHMI II for nurses and physicians, using lecture material and videos developed by Chicago. Because TASHMI II was a teaching facility, the instructors used the hospital NICU to provide training for medical and nursing students. In April 1997, the partners opened a neonatal resuscitation training center at TASHMI II at the site of the specially equipped NICU. Through 2002, the
center trained physicians, nurses, and midwives from both the TASHMI II and other health institutions in the region through MOH-certified monthly courses in neonatal resuscitation. In May 1998, the partners opened a second neonatal resuscitation training center at the maternity house of Khorezm Oblast Hospital in the city of Urgench. Instructors at Urgench centers were prepared through training programs held in both Chicago and Tashkent.

Program Impact

It is important to assess the impact of any program aimed at improving capacity building. However, when programs are volunteer-based and individual efforts, it is hard to generate data required to measure the impact. Nevertheless, some indirect measures indicate the scope of the impact (Table 2).

The Indo-United States faculty exchange program resulted in training more than 100 Indian pediatric faculty in neonatology and in the NRP. The partnership resulted in training of faculty from multiple disciplines and, thus, capacity building of an institution. The program also facilitated the institution’s ability to compete for National Institutes of Health funding through the Global Network Program.

The impact of the UIC/TASHMI II program was well described in the program evaluation by external evaluators for AIHA. (6) “As a result of a partnership program, the following treatments and procedures were introduced into neonatology clinical practice at TASHMI-II: infusion therapy, monitoring of critically ill newborns, patient assessment using blood-gas indicators, application of state of the art resuscitation techniques, use of ‘butterfly needle’ and endoscopic, bronchoscopic examinations. Tashkent partners mastered intubation and extubation techniques, umbilical vein and artery catheterization techniques and skills associated with respiratory equipment, cardiac monitors and defibrillators and care of premature and critically ill newborns. The

Table 2. Major Impacts of UIC International Programs

India:
1. Introduction of Neonatal Resuscitation Program through National Neonatal Forum
2. Facilitation of training of faculty from most of the states of the country
3. Development of institution-to-institution collaboration
4. Establishment of a model regional perinatal center, including a transport system
5. Facilitation of grants from the National Institutes of Health Global Network and March of Dimes

Poland and Lithuania:
1. Establishment of regional perinatal programs
2. Joint publication of textbook of neonatology in Poland
3. Faculty training in research and initiation of collaborative research
4. Government policy changes (perinatal program) through the efforts of the local professional leadership
5. Establishment of collaboration in nursing discipline

Uzbekistan: TASHMI II Uzbekistan Partnership
1. Development of neonatal intensive care unit
2. Development of women’s wellness center
3. Establishment of learning resource center and neonatal resuscitation training center
4. Government policy change (neonatal resuscitation program and women’s program)
Tashkent/Chicago partnership also helped to bring about national policy-level changes.”

Equally importantly, the collaborative efforts resulted in a policy decision by the Uzbek MOH. The recommendations for organization of a neonatal resuscitation program and development of a perinatal program developed jointly by UIC and the MOH were institutionalized in 2001 by MOH Decree No 25. Also, the partnership-developed course on neonatal resuscitation is now part of the Tashkent Medical Academy undergraduate curriculum. Since their openings in 1997 and 1998–2002, the Tashkent and Urgench neonatal resuscitation training centers have provided training to 1,190 and 298 health professionals, respectively, an example of the benefits of the train the trainer program.

The previously described programs in Uzbekistan were service-oriented, with no research component to the program. Nevertheless, AIHA studied the impact of institutional partnerships on neonatal outcome across NIS and eastern European countries. Data were obtained on 8,386 newborns from 16 hospitals from NIS countries. Significant improvements in clinical outcomes were documented when the critical number of trained staff was more than 25%. In another study of 15,000 deliveries, the investigators noted improvement in Apgar scores between 1 and 5 minutes and reduction in deaths due to perinatal asphyxia, respiratory distress syndrome, and meconium aspiration syndrome when 100% of the staff were trained in the NRP. (6)

Summary

Shortages in the global health workforce is one of the major concerns for national policymakers. This is also a major impediment to achieving the Millennium Development Goal #4, the reduction of child mortality by 2015. (9) Awareness of and interest in filling the workforce gap has grown among the developed nations.

Training of individual members has made invaluable contributions to technology transfer and capacity building, but this is a long process. Institution-to-institution collaboration seems to have a much better and faster impact. Success of such collaborations required fiscal commitments of governments or nongovernmental not-for-profit organizations and cooperation of developing countries.

Further, successful collaboration depends not only on strategic planning (Table 3) but also on key human elements. It is important for the institution planning to initiate an international program to offer orientation to their participating staff in regional history and culture. Members planning to work in developing countries must develop cultural sensitivity and skills in interpersonal relationships as well as tolerance for work in resource-poor countries. Some guidelines are given in Table 4.

The AIHA model of multinational, multi-institutional twinning for technology transfer has a great potential for reduction of IMR in other parts of the world. Such plans might enable us to meet the Millennium Development Goal #4 by the target date of 2015. (9)

ACKNOWLEDGMENTS: I would like to thank all my professional colleagues, (doctors, nurses, administrators) at UIC, colleagues from other United States institutions (there are too many names to mention), and colleagues in our host countries without whose help the faculty exchange program at UIC would not have been successful. I thank the financial support of the following organizations: PNA, Mercy Lift,
AIHA/USAID/. I thank Jim Smith, Executive Director of AIHA, Washington, DC, for giving me the permission to use the AIHA web-posted data on NIS partnership programs. I also thank Ann Dantzler for her help in preparing this manuscript.

References
International Perspectives: Models of Technology Transfer to Developing Countries: Experience of Three Decades

Dharmapuri Vidyasagar

*NeoReviews* 2009;10:e1-e9
DOI: 10.1542/neo.10-1-e1