



Published in final edited form as:

Lancet Oncol. 2010 February ; 11(2): 204–210. doi:10.1016/S1470-2045(09)70288-8.

Teleoncology: Current and future applications for improving cancer care globally

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Abstract

Access to quality cancer care is often unavailable not only in low- and middle-income countries but also in rural or remote areas of high-income countries. Teleoncology (oncology applications of medical telecommunications, including pathology, radiology, and other related disciplines) has the potential to enhance both access to and the quality of clinical cancer care as well as education and training. Its implementation in the developing world requires an approach tailored to priorities, resources, and needs. We believe that teleoncology can best achieve its proposed goals through programmatic, consistent, and long-term application. Here we review teleoncology initiatives that have the potential to decrease cancer care inequality between resource-poor and resource-rich institutions and offer guidelines for the development of teleoncology programs in low- and middle-income countries.

Keywords

teleoncology; telemedicine; pediatric oncology; telepathology; developing countries; underserved patients

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Disclosure: The authors have no financial or other conflict of interest related to the contents of this article. Since some of the teleoncology programs mentioned are conducted at King Hussein Cancer Center (KHCC) and the International Outreach Program (IOP), it should be noted that Dr. Qaddoumi worked at KHCC in Amman, Jordan, from October 2002 until September 2007 and has been with the IOP since October 2007.

CONTRIBUTORS

Ribhi Hazin: Conception, design, literature search, data collection, data analysis, manuscript writing, and final approval of manuscript.
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Search strategy and selection criteria

Data for this Review were identified by searches of MEDLINE and PubMed using the search terms "teleoncology", "telemedicine", and "cancer" or "chemotherapy". Abstracts and meeting reports were excluded. Only reports published in English between 1993 and 2009 were included. Useful websites for further information include the World Bank (www.worldbank.org), the United Nations (www.un.org), and the world fact book at the Central Intelligence Agency website (www.cia.gov).

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CANCER CARE DISPARITY: A GLOBAL PROBLEM

There are gaps in cancer care globally. The inadequacies in low- and middle-income countries (LMC) are most widely recognized. The World Health Organization (WHO) recently reported that the further development of LMC is hindered by the significant morbidity and mortality of chronic disease.¹ An estimated 80% of chronic disease deaths occur in LMC,^{1,2} which lose more lives each year to a single chronic disease—cancer—than to HIV/AIDS.²

National economic status is an important element in access to modern cancer care. The World Bank classifies nations by gross annual per-capita income as low-income countries (LIC, US \$935 or less), middle-income countries (MIC, \$936–11,455), and high-income countries (HIC, \$11,456 or more). MIC are further divided into lower (\$936–3,705) and upper (\$3,706–11,455) MIC.

The global incidence of cancer is projected to increase by 50% over the next 20 years,³ and most cases will occur in LMC,² which possess only 5% of the world's resources. Further, children are not spared; for example, cancer is the second most common cause of death in children in many Latin American countries,⁴ although as many as 70% of pediatric cancers are curable with the appropriate diagnosis and treatment.⁵

HIC have disparities in cancer care as well, usually involving the unavailability of specific specialties, diagnostic facilities, and treatment infrastructure in remote or rural areas.⁶ These disparities are likely to increase; in the United States (US), a shortage of approximately 3800 oncologists is projected by the year 2020.⁷

THE POTENTIAL OF TELEONCOLOGY

Systematic and effective communication between individuals at advanced oncology centers and those at remote or resource-poor centers can improve cancer care and enhance opportunities for continuing clinical education. Therefore, disparities in cancer care can be reduced by the development of resources—human capital and telecommunication infrastructure—that link institutions with different levels of funding and expertise (Figure 1).

Telemedicine is defined variously, but the definitions used by WHO, the European Commission, and the American Telemedicine Association center on the “use of telecommunication to advance health”. Teleoncology is the application of telemedicine to oncology, including diagnostics (laboratory, radiology, pathology), treatment (surgery, radiation oncology, medical oncology), and supportive (rehabilitation and palliative) care. Therefore, teleoncology includes any telemedicine application used to advance cancer care.⁸ Data derived from telemedicine in general will be provided where it informs potential teleoncology efforts.

TELECOMMUNICATION TECHNOLOGIES

Several communication technologies can support effective teleoncology. Synchronous (real-time) interactive videoconferencing is one of most common.⁹ A fully equipped videoconferencing unit with six integrated-services digital network (ISDN) transmission channels (384 kb/s) is costly and requires technical support that is not available in many LMC.⁹ However, more affordable systems may be feasible. In Ecuador, a videoconference unit using a modem for transmission (56 kb/s) was recently installed for less than US \$1000,¹⁰ although it has not been assessed for teleoncology applications.

Many collaborative internet protocols that allow synchronous interaction among participants have recently emerged. Some of these, collectively termed web conferencing protocols, are very robust and support voice and visual teaching applications such as slide presentations. The main advantages of these systems are their low cost and minimal technical maintenance requirements. A web conferencing initiative hosted by the St. Jude Children's Research Hospital (SJCRH) site Cure4Kids (www.cure4kids.org) has been successfully used for 6 years to support the hospital's International Outreach Program partners.¹¹

The high-end synchronous systems, such as telesurgery systems,¹² robotic telesurgery,¹³ and virtual microscopy,¹⁴ are likely to be used only in resource-rich countries. Because they can transmit high-resolution images for clinical, pathological, and radiological diagnosis, many hospitals in the US and Europe use them to overcome local lack of expertise. Table 1 describes the advantages and disadvantages of current methods of synchronous telecommunication.

Asynchronous interaction, also known as the store-and-forward method, uses software applications to transmit, store, and retrieve data or digital images.¹⁵ Store-and-forward communication is practical in fields that require imaging. As an example, the nonprofit organization ORBIS (www.orbis.org) links clinicians in developing countries with mentors in developed countries to improve the diagnosis and management of ocular diseases, including cancer.¹⁶ Retinal images obtained via fundus or retinal camera can be uploaded to the ORBIS site, which also supports related MR, CT, and ultrasound images, allowing full consideration of specific case details by the mentor (Figure 2). Telepathology frequently uses store-and-forward methods.¹⁷ One of the earliest non-real time telemedicine initiatives, SateLife, began in 1991 and continues to support e-mail consultations, teleconferencing, and online educational content via a low-orbit satellite.¹⁸ Finally, e-mail is a widely used but under-reported method of teleoncology.^{19,20}

TELEONCOLOGY IN HIGH-INCOME COUNTRIES

Improvement of outcomes in underserved areas and dispersed populations

Europe—The regions and countries of Europe are heterogeneous in their resources, populations, and needs, and cancer outcomes can vary accordingly.²¹ Table 2 provides several examples of successful teleoncology initiatives launched at the continental or national level.

In response to widely disparate rates of breast cancer recurrence at European hospitals (10.5%–36% after breast-conserving therapy and 4.6%–21.3% after mastectomy),²² the Clinical Oncology Network for Quality in European Standards of Treatment (CONQUEST) initiative was launched.²¹ Another continent-wide project is the Trans-European Network for Positron Emission Tomography (TENPET), which supports teleconsultation for the performance and interpretation of PET scans.²³ The International Union Against Cancer's Telepathology Consultation Center¹⁷ and the i-Path²⁴ system are widely used to support pathology consultation in Europe. At the national level, Norway²⁵ in 1996 became the first country to reimburse providers for telemedicine services.²⁶ Scotland²⁷ and Germany²⁸ have implemented teleoncology systems for treatment planning for breast cancer and Hodgkin lymphoma, respectively.

The United States—Like Europe, the US has underserved populations. There is substantial evidence that cancer outcomes are worse in rural or remote areas.^{6,29} Onega et al⁶ proposed that specialty cancer care be delivered via teleoncology in the US to decrease the travel burden and improve access. The many successful and sustainable teleoncology initiatives in the US include cancer care for the widely dispersed US military population³⁰

and a well known teleoncology application developed by Kansas University Medical Center to serve its large rural patient base^{31,32} (Table 2). Gaps in care are greater in rare oncology subspecialties such as cancer genetics.³³

Other high-income countries—Japan's teleoncology cancer center network³⁴ conducts approximately 130 teleconferences per year attended by 16,000 people and hosts regular telepathology and teleradiology meetings. A program developed by the WHO to meet the surging need for oncology care after the Chernobyl catastrophe³⁵ links Nagasaki University to two hospitals in Belarus and Kazakhstan.³⁶ Both New Zealand³⁷ and Australia³⁸ have active teleoncology services for skin cancer (Table 2).

Improvement of outcome in clinical trials

The negative impact of errors in diagnosis,³⁹ staging,⁴⁰ and treatment delivery⁴¹ is well documented by retrospective studies. For example, 30% of patients who had a diagnosis of high-grade glioma were subsequently found to have had low-grade glioma.³⁹ These patients underwent unnecessarily aggressive therapy that could have been prevented by protocol-directed prospective (i.e., before treatment) telepathology review. Packer et al found, at the end of a medulloblastoma study, that patients who had received inadequate radiological staging were less likely to survive.⁴⁰ Donaldson et al found that the 5-year local control of Ewing's sarcoma was 80% with the correct dose and volume of radiotherapy⁴¹; however, in the same cohort, patients with minor and major treatment deviations had 5-year local control rates of only 48% and 16%, respectively. Rapid expert opinions at the time of staging and treatment planning can improve patient outcomes, improve the integrity of clinical trials data, and build the expertise of local cancer teams.

TELEONCOLOGY IN LOW- AND MIDDLE-INCOME COUNTRIES

Limiting factors

Teleoncology is less available in LMC than elsewhere. However, internet access is now readily available in all major cities of Africa,⁴² and wireless high-speed internet service (using less costly medium-orbit satellites) is being introduced in LMC by commercial providers. Desktop computers can be purchased for less than \$200, and laptops with wireless connectivity have been produced for less than US\$100 by the nonprofit organization One Laptop Per Child. China and India have almost 37% of the world population, have their own space programs and high-speed internet service, and manufacture all equipment required for teleoncology. However, despite these resources, official telemedicine activity began in China only in 1995.⁴³ We believe that human factors, rather than lack of resources and technology, is often the main obstacle to teleoncology in LMC.⁴⁴ As Ganapathy stated elegantly, "what is required is not implementing better technology and getting funds, but changing the mindset of the people involved".⁴⁵ In China there has recently been a proliferation of telemedicine units, that has not been matched by a similar increase in human resources, leaving many such units underutilized.⁴⁶ In India, a fully equipped videoconference connection was established between two centers 1500 kilometers apart to help in neurology, a rare specialty in India, in which the whole country has only 750 neurologist.⁴⁷ Over a 4-year period only 22 successful sessions were held.⁴⁷

In many LMC,⁴⁴ conflicts over professional and political power, fear of change, reluctance to seek a second opinion, and other human factors have obstructed the optimal use of this system.

Successful teleoncology initiatives in LMC

There have been several successful teleoncology initiatives in LMC, although more are needed. India has one of the largest telemedicine operations in the developing world, with participation by both private and public sectors.^{3,45,47,48} Other experiences from Cambodia,⁴⁹ Solomon Islands,⁵⁰ Brazil,⁵¹ and Jordan.^{9,16,20} are summarized in Table 3. We will emphasize the Cure4Kids experience as an example of a successful sustained international teleoncology experience.

The Cure4Kids website (see above) is an excellent, sustained teleoncology service linking providers in LMC with experts in HIC.¹¹ The site regularly hosts synchronous discussions of specific diseases,⁵² data management,⁵³ and other oncology issues⁵⁴ by staff at St. Jude and its partner sites. More than 4,000 oncology professionals attended the online live meetings hosted by Cure4Kids from 2002 through 2008.⁵⁵ The site also offers extensive multilingual educational material that has been accessed more than 2.5 million times. The pediatric oncology nursing course alone has been viewed more than 120,000 times.⁵⁵ The site was created by the St. Jude International Outreach Program (IOP), established in 1994 to improve the survival rates of children with catastrophic illness worldwide through the transfer of knowledge, technology, and organizational skills.⁵⁶ A detailed analysis of success factors during the first decade of IOP experience⁵⁶ revealed the importance of sustained efforts and an emphasis on the human factor.^{52,56} Teleoncology in retinoblastoma through ORBIS, Cure4kids, videoconferencing, or e-mail was a major component in IOP initiatives in Central America⁵² and Jordan.¹⁶ Such long-term involvement with the partner sites helped to build trust and contributed to the “change in mind set” that facilitated the rapid acceptance of teleoncology.

Finally, teleoncology experiences reported in languages other than English⁵⁷ or in publications not available through PubMed may be underrepresented here. For example, the Mexican National Center for Health Technology Excellence (www.cenetec.salud.gob.mx) provides detailed guidelines in Spanish for use of the Mexican telemedicine program (which includes teleoncology).

GUIDELINES FOR PLANNING TELEONCOLOGY PROGRAMS LINKING INSTITUTIONS IN HIC AND LMC

LMC are heterogeneous in their needs, communication infrastructure, and resources. We believe that teleoncology programs that are customized to these features have the greatest potential to improve cancer care. We offer the following guidelines to those planning to develop teleoncology initiatives in such countries.

Focus on the human factor

There is little available information about the attributes necessary to ensure the success and sustainability of telemedicine programs.^{58,59} Many of those identified are human factors that suggest that a telemedicine program must have grass-roots, “bottom up” support.⁵⁸ The available reports also stress that clinicians, not politicians, should be the decision makers⁵⁸ and that efforts should focus on solutions to current health problems.^{58,59} Otherwise, telecommunications equipment may be purchased but languish in disuse due to political conflict, competing priorities, or miscommunication.⁵⁹ It is also important that clinicians be trained to use the equipment⁵⁸ and that local technical staff be instructed in updating antivirus software and maintaining the equipment.⁶⁰ A study comparing private- and public-sector telemedicine in India found that the former is more successful in improving clinical medical services.⁴⁸ The authors attributed this finding to the needs-based approach of the private sector as compared to the top-down approach characteristic of public programs.

Build on twinning programs

Teleoncology enhances and builds on established programs. Teleoncology initiatives in LMC often work best in the context of a “twinning program” linking existing local cancer centers⁶¹ to cancer centers in HIC. Evidence to date suggests that twinning improves cancer survival in LMC,^{52,56,63} and the integration of teleoncology into twinning programs maximizes clinical benefits and the effective use of resources.^{16,19,52} To ensure broader benefits, the partner sites in LMC should be encouraged to establish local, regional, or national networks. Further, cooperation among multiple cancer centers within a single LIC or MIC, and between those in different LIC and MIC, should be promoted. Figure 3 illustrates the proposed model. Such multi-tier telemedicine projects have been suggested³ or piloted^{51,57,64} in LMC but to date have lacked the element of twinning with HIC cancer centers.

Tailor the approach to the country and targeted diseases

The first principle of a successful teleoncology system is “pragmatic selection” of goals and methods on the basis of needs and resources rather than politics and publicity.⁵⁸ Therefore, teleoncology programs in lower-MICs (e.g., Jordan^{9,16}) or upper-MICs (e.g., South Africa⁶⁵) cannot realistically be used as models for programs in LICs (e.g., Yemen or Nigeria). Even within the MIC group, a lower-MIC (per capita income, US\$936) is not comparable to an upper-MIC (per capita income, \$11,456). To ensure an optimal clinical cost-benefit ratio, the needs and available resources of a specific country should dictate the objectives and the approach used for teleoncology within that country. The cancers to be targeted must be chosen similarly, on the basis of need, existing infrastructure, resources, and the complexity of the required treatment. For example, it would be a misuse of resources for a country like the Solomon Islands, which has no pathologist and whose internet bandwidth connections are limited,⁵⁰ to invest in videoconference units or to start a retinoblastoma eye salvage program. Instead, this nation, with the help of cancer centers in HICs (Switzerland, Germany, and Australia) developed a practical, effective, and economical system that utilized an existing telepathology resource (iPath) based at Basel University (Switzerland). Further, an e-mail interface was added to overcome the limited internet connections in the Solomon Islands.

Involve allied health professionals

Nurses, technicians, and even medical and nursing students. The lack of specialty physicians can hinder teleoncology initiatives in many LMC. We propose that nurses and other allied health professionals can help to fill the gap by taking on additional training and responsibility. In both of the teleoncology initiatives in Jordan, the specialized nursing staffs of the neuro-oncology and ocular oncology services⁶⁶ provided indispensable support,^{9,16} and their disease-specific skills greatly improved clinical care.⁶⁶

In Brazil, a 150-minute training session on melanoma allowed first-year medical students to accurately diagnose melanoma via a telemedicine model.⁶⁷ In another pilot project, a medical student from Emory University (US) spent 6 weeks in the Solomon Islands and was able to conduct 8 teleconsultations with his mentors in the US after 1 hour of training in the use of the system.⁶⁸ After the student departed, the local Solomon Islands team used this pilot telemedicine system to conduct 60 more teleconsultations.

Avoid sophisticated technologies

Advanced methods such as Tesynegy,¹² virtual microscopy,¹³ and robotic telesurgery¹⁴ are unlikely to significantly improve health care in LMC.⁶⁹ Expensive technologies invite the mismanagement of funds and may actually increase the gap in cancer care if access is

available only to the wealthy.⁶⁹ As the costs of these approaches decrease in the future, they may become more accessible; however, in general they should be discouraged if they do not offer a clear benefit. Less expensive options, as discussed above, should be selected as appropriate for local needs and resources.

Expensive technologies that offer a clear advantage, such as videoconferencing, may already be in use for other purposes in LMC. We suggest that the use of existing equipment and resources be explored as an alternative to purchasing new units for teleoncology. For example, the nongovernmental organization Medical Missions for Children, with support from commercial corporations, has established active videoconferencing capabilities for pediatrics in 58 LMC.⁷⁰ In addition, many banks and other institutions in HIC and LMC acquire videoconference units to unify their organizations and expedite communication (www.tandberg.com). Such institutions may readily lend their units to local health care providers for a few hours per month as a goodwill or public relations gesture. Finally, many private hospitals in LMC (as in India⁴⁸) own telemedicine units that could be used for health care in the public sector if appropriate private- and public-sector cooperation is established.

OTHER POTENTIAL APPLICATIONS OF TELEONCOLOGY IN LMC

Linkage of resource-rich and resource-poor institutions within countries

Many large LMC, such as India, China, Russia, and Brazil, have tertiary cancer centers in their major cities that can serve as regional hubs, extending resources and expertise to peripheral hospitals (see model, Figure 3). India's OncoNET⁴⁸ project for public hospitals is one such initiative that has reduced the burden of referrals to tertiary centers and improved cancer care and education in peripheral hospitals. Datta and Rajasekar proposed a three-tier model for radiation therapy facilities in India that depends on resources available at each level of therapy.³ Similar initiatives exist for pathology in Russia⁵⁷ and for pediatric oncology in Brazil.⁵¹ A similar telemedicine program (applicable to teleoncology) is being developed in Argentina to connect hospitals in rural areas with tertiary centers.⁶⁴

Support of clinical investigation

Many of the advanced cancer centers in upper-MIC are equipped to participate in international clinical trials, although other centers may benefit from assistance in developing the regulatory and clinical best practices necessary to support such trials. Programmatic telecommunications offers a feasible approach to the training and mentoring of health care professionals in establishing and overseeing these important elements of human research. The integration of teleoncology into international clinical trials will also help to ensure data integrity and patient safety in both LMC⁷¹ and HIC³⁹⁻⁴¹ and, most importantly, will create local capacity for clinical investigation. It may also allow more cancer centers in MIC to participate in clinical trials, thus expediting accrual—an especially important consideration in rare cancers—and benefiting all participants.

Improvement of quality of life of cancer patients

Cancer is commonly accompanied by suffering (pain, dyspnea, and other discomfort). However, resources and expertise in palliation are least likely to be available, and suffering is least likely to be adequately addressed, in LMC,⁷² especially in rural areas.⁷³ Telemedicine has been utilized in hospice care,³² and similar uses should be explored in LMC. Telemedicine links between HIC and LMC can be established to improve palliative care in major centers, and links between resource-rich and resource-poor institutions within LMC can then improve palliative care in remote or rural areas.⁷³ Such links should also be explored to provide or improve ancillary services such as rehabilitation, social work, child life, and others needed to optimize quality of life in cancer patients.

CONCLUSION

Teleoncology is not a panacea for global oncology problems. If it is not used wisely, or if the “human factor” is not addressed, it can even exacerbate existing problems. Implementation of teleoncology should be guided by local communities’ needs and introduced to potential stakeholders as a pragmatic means of enhancing access to oncology care. Local professionals should be recruited as stakeholders and provided with thorough training. When done well, teleoncology is, as Furtado commented, the “next-best thing to being there.”⁷⁴

Acknowledgments

This work was supported in part by grant CA21765 from the U.S. Public Health Service and by the American Lebanese Syrian Associated Charities (ALSAC). The manuscript was edited by Sharon Naron. The artwork was supported by Klo Spelshouse and Elizabeth Stevens. The authors thank Raul Ribeiro, MD, for critical review, information, and advice throughout the project; Eric Bouffet, MD, for helpful review; and Yuri Quintana, PhD, for technical advice.

Funding: None other than that reported above.

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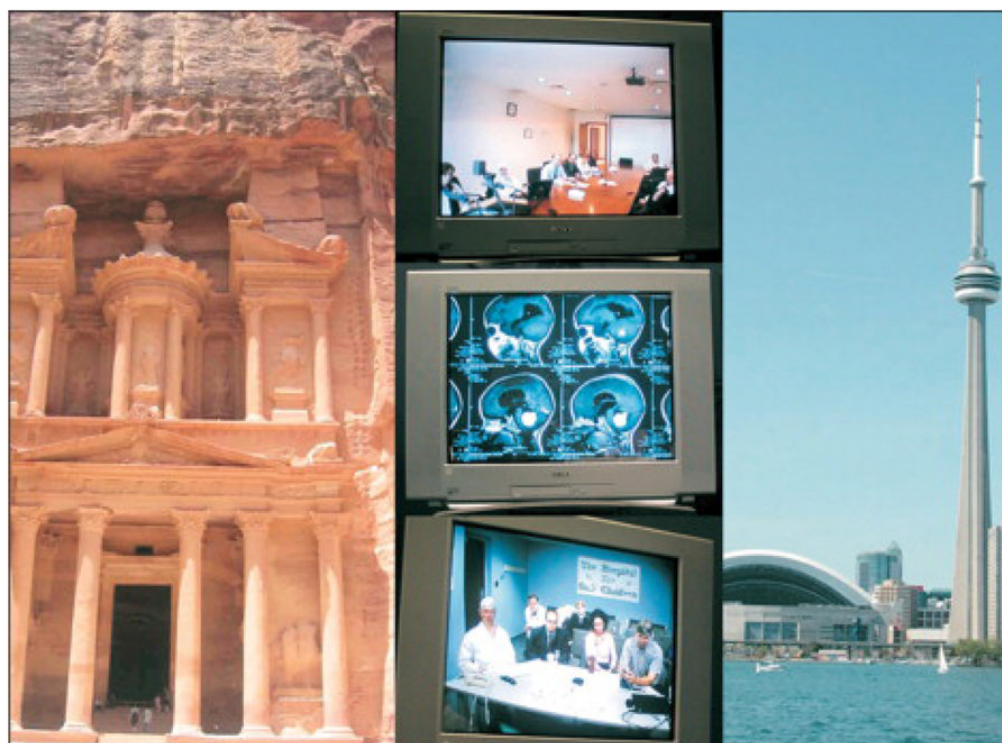


Figure 1. Teleoncology links ancient and new worlds. Left, the ancient city of Petra, Jordan. Right, the CN Tower, Toronto, Canada. Central images show a monthly videoconference that allows the neuro-oncology teams of King Hussein Cancer Center (Amman, Jordan; top) and Hospital for Sick Children (Toronto, Canada; bottom) to view and discuss complex brain tumor cases (center). The ongoing videoconference series began in 2004.

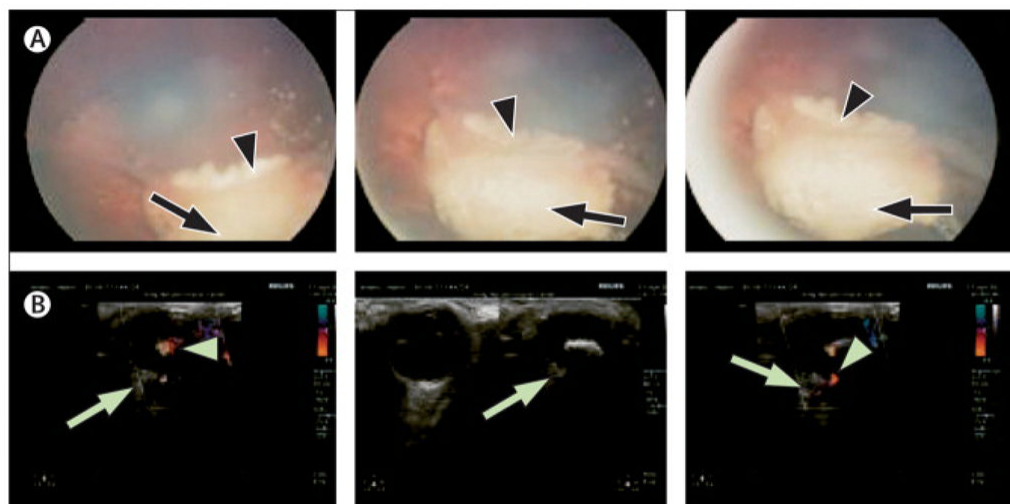


Figure 2. Presurgical ocular teleoncology consultation. A complex case of bilateral retinoblastoma was treated in Jordan. The policy at the Jordanian center required that cases be discussed with the mentoring St. Jude Children’s Research Hospital ocular oncology team before any major intervention. Images show the right eye after chemotherapy. (A) Retinal photographs show tumor (arrows) and retinal folds (arrowheads). (B) Doppler ultrasound images show tumor (arrows) and active blood flow (arrowheads). Because blood flow suggested viable tumor, enucleation was initially considered. The mentoring team recommended observation, as blood flow appeared to be localized in the retinal fold. Although the left eye required enucleation, the right eye was salvaged and the young patient retained useful vision.

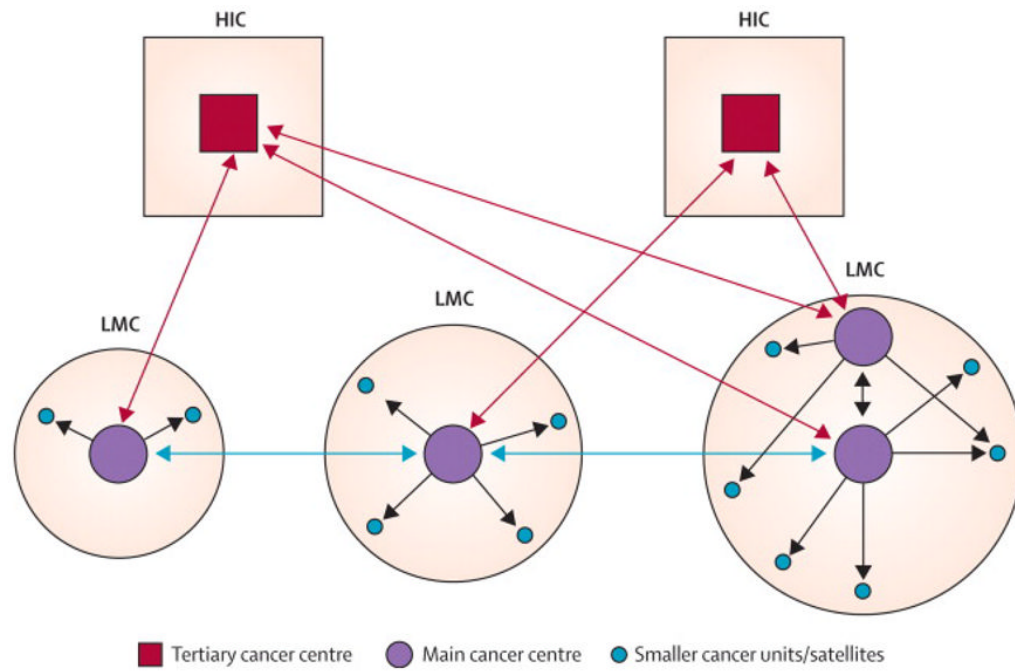


Figure 3. Proposed multi-tier collaborative teleoncology scheme linking cancer centers. Teleoncology would be implemented at the international level between cancer centers in HIC and those in LIC/MIC (red arrows) and between cancer centers in different LIC/MIC (orange arrows). The scale of the programs would depend on the population and number of cancer centers; a more extensive program would be appropriate for a large LIC/MIC with more than one cancer center (example at lower right). The level of technology used would depend on needs and resources. The main centers within each country would communicate with each other via advanced teleoncology such as videoconferencing and (using less expensive technology) would mentor smaller cancer units (gray arrows).

Table 1

Advantages and disadvantages of synchronous technologies applicable to teleoncology

Technology	Advantages	Disadvantages
Web conferencing	Low cost Wide availability	Limited resolution of images Images cannot be manipulated Participants may not see each other ^a
Videoconferencing	Good image resolution Images can be manipulated Participants can see each other Readily available Can present/interview patients Supports image-intensive clinical case collaborations (diagnosis, radiation/surgery planning, disease monitoring)	Expensive Requires maintenance
Telesynergy [®]	A multimedia workstation integrates all components for collaborative multidisciplinary teleoncology High image resolution Transmits images from their primary sources Allows image manipulation Supports comprehensive multidisciplinary case review and discussion Supports collaborative planning of radiation and surgery	Very expensive Requires ~ 20 ISDN channels Requires many peripheral components Difficult to install Requires intensive maintenance Requires dedicated storage space
Virtual telemicroscope	Operator can control microscope without special hardware or software Good image resolution	Limited to pathology Expensive Performance depends on the user's computer
Robotic telesurgery	Circumvents hand tremors Supports fine surgical movements	Bulky equipment Very expensive Requires special training

^a A significant increase in bandwidth and expense would be required.

Table 2

Summary of teleoncology initiatives in high-income countries

Initiative	Service area	Field(s)/Disease	Goal(s)	Method/Technology	Reference(s)
CONQUEST	Europe	RT Oncology	QA Improve CT Access to MR	Videoconference	21
TENPET	Europe	Radiology	PET scans QA	Interactive Store and forward	23
UICC-TCC ^a	Europe	Pathology	Consultation	Web-based	17
i-Path ^a	Europe	Pathology	Consultation	Web-based Email-based	24,48
QA for RT	Norway	RT	Discuss RT planning	Videoconference	25
TELEMAM	Scotland	Breast cancer	Randomized trial ^b	Videoconference	27
TeleRT network	Germany	RT Lymphoma	Centralized RT review QA Improve CT Education	Videoconference Store and forward	28
VISN service area 20	US military (AK, ID, OR, WA)	Oncology	MDTB for dispersed populations Improve referrals	Videoconference	30
Kansas University Medical Center	US (rural KS)	Oncology Hospice	Serve rural populations	Videoconference	31,32
Cancer genetic counseling	US (rural NC)	Genetic counseling	Serve rural areas	Videoconference	33
NCC network	Japan	Oncology Radiology Pathology	MDTB Education	Videoconference	34
IPHECA	Belarus, Kazakhstan	Thyroid cancer Radiology Cytology	Assist affected populations	Communication satellite	35,36
Teledermatology	New Zealand	Skin cancer	Serve rural populations	Videoconference	37
Teledermatology	Australia	Skin cancer	Serve rural populations	Email (digital images)	38

RT, radiotherapy; QA, quality assurance; CT, clinical trials; MR, medical records; TENPET, Trans-European Network for Positron Emission Tomography; UICC-TCC, International Union Against Cancer Telepathology Consultation Center; NA, not available; VISN, Veterans Integrated Service Network; AK, Alaska; ID, Idaho; OR, Oregon; WA, Washington; MDTB, multidisciplinary tumor board; KS, Kansas; NC, North Carolina; NCC, National Cancer Center; IPHECA, International Program on the Health Effects of the Chernobyl Accident

^aEuropean-based telepathology initiatives that are also used widely in LMC, especially Asia and Africa.

^bA randomized trial of consultation in person vs. via videoconference, showing no difference in clinical effectiveness

Table 3

Summary of teleoncology initiatives in low- and middle-income countries

LMC	Mentoring HIC	Field	Technology	Goal(s)	Ref
India	None ^a	Radiation oncology Cancer detection, treatment, and pain relief	Videoconference Videoconference	Establish a 3-tier radiation oncology network Decrease referrals Education	3 48
Cambodia	USA	Consultation	E-mail	Second opinion	49
Solomon Islands	Europe (i-Path)	Pathology	E-mail	Second opinion	50
Brazil	None ^a	Pediatric oncology	Videoconference	Establish a cancer network	51
International (Cure4Kids) ^b	USA	Pediatric oncology	Web conferencing	Twinning Specific diseases Data management	11 52 53
Jordan	Canada	Pediatric neuro- oncology	Videoconference E-mails	Second opinion Build local expertise	9 20
	USA	Pediatric ocular oncology	Web-based (Orbis)	Team structure	16

^aThese initiatives in India and Brazil are designed to link resource-rich with resource-poor institutions or networking in each country and not for twinning with centers in HIC.

^bCure4Kids is used to facilitate twinning and telemedicine between centers in HIC and LMC.