

Expanding the Reach of Health Care in Developing Nations with WiMAX

How Wireless Connectivity Can Improve the Quality and Efficiency of Health Care

Monica Paolini
Senza Fili Consulting
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Developing nations face urgent challenges in improving access to and the effectiveness of their health care systems with very limited financial and human resources. With technologies like Worldwide Interoperability for Microwave Access (WiMAX), wireless broadband connectivity is set to play a growing role in meeting the World Bank goals of increased affordability and efficiency of health care in developing nations. WiMAX brings real-time wireless broadband connectivity to remote and mobile workers, clinics, and hospitals and has the potential to greatly increase access to and quality of health care, expand the availability of training to the health care workers, and improve epidemiological and demographic data collection.

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WiMAX provides secure, real-time connections to support voice, data, and video applications, in both fixed and mobile environments. It allows health care workers to have access to patient records and medical reference information, to send their colleagues test data to be analyzed, to rely on specialists for guidance or remote consultations, and to have access to online, video-based training. Patients are empowered with more comprehensive health care services provided by nurses and doctors they know and trust, with wider access to information and education, and with more extensive preventive care. Lower equipment costs and cooperation with operators make adoption of wireless broadband affordable in developing nations. Successful adoption of services requires supportive policies and a willingness to experiment with new business models in which public and private organizations can mutually benefit from cooperation.

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Improving quality of and access to affordable health care

Bringing health care where it is needed. Today, patients have to travel to the closest clinic or hospital to receive basic treatment, and to more distant institutions for specialized or emergency care or for hospitalization. This model does not provide comprehensive and efficient access to health care in developing nations. With 56% of the population in 2007 living in rural areas¹, some of which are not reachable by road, ill patients often lack the time and resources to reach the closest clinic. In urban areas, one third of the population lives in slums² where clinics are few, overcrowded, and poorly funded.

Reliable, always-on broadband wireless connectivity makes a new health care model possible: instead of asking the patient to go to the nearest clinic or hospital, the mobile health care worker reaches out to the patients where they live and when they need care, bringing access to a broad set of medical resources through voice, data, and video applications.

Reaching out to remote health care workers and clinics. In addition to the individual mobile health care worker, WiMAX networks can provide a data connection to a variety of health care facilities: local clinics that do not have wireline broadband connectivity³, mobile clinics (e.g., hosted in buses) that operate in multiple locations, temporary clinics that may be set up for a specific purpose (e.g., a vaccination

¹ United Nations, 2007. In the least developed countries, the number is 72%.

² United Nations Population Fund, 2007. In the slums of Nairobi, access to health care is even more limited than in rural areas. The infant mortality rate is 20% higher there and immunization levels are 25% lower, according to the United Nations Population Fund Africa Population and Health Research Center (2002), *Population and Health Dynamics in Nairobi's Informal Settlements*.

³ According to Dr. Gregory Cline, Healthcare Business Development Manager at Intel, in South Africa almost 95% of rural clinics still lack voice connectivity.

drive), or ambulances. A wireless broadband connection can also support basic voice services that can be made accessible to the staff through low-cost Wi-Fi phones.

In sparsely populated areas in Ontario, Canada, more than 32,000 remote video consultations per year with specialists improve health care access for residents visiting local clinics. According to Cisco estimates, they save US\$8 million in medical-related travel costs per year.

The government of India has adopted an ambitious plan to roll out mobile clinics in rural areas to offer telemedicine and e-education applications⁴. Each local health center relies on mobile clinics to reach remote patients. Volunteers are recruited in each village to coordinate health care activities and monitor for early signs of epidemics and for other situations that require immediate attention. Access to data connectivity is crucial to volunteers, who typically have no medical training; it enables them to send data or photographs or arrange for video calls to exchange information and get guidance.

In Pakistan, Cisco is working on a trial that combines satellite and WiMAX connectivity to mobile units that provide earlier oncological screening to rural patients. Female patients feel more comfortable seeking care in a familiar environment, close to their homes. Earlier screening allows doctors to detect breast cancer in women when it is still treatable.

“Information and communication technologies enable people in remote areas to have access to services and expertise otherwise unavailable to them, especially in countries with uneven distribution or chronic shortages of physicians, nurses and health technicians or where access to facilities and expert advice requires travel over long distances,” World Health Organization, 2008.

⁴ Ministry of Health and Family Welfare, India (2005) National Rural Health Mission.

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**Bringing health care closer to the patient:
what are the gains?**

Improved health levels among the population, translating into longer life expectancy, improved quality of life, and increased work productivity⁵.

Reduction in waste of resources due to unnecessary referrals and hospitalization⁶ or to late intervention, in turn reducing funding needs.

Quicker and more effective response to epidemic outbreaks.

Increased trust in and reliance on the health care network by underserved communities, thanks to closer ties to health workers. According to a 2008 report by the World Health Organization, "Access to the same team of health-care providers over time fosters the development of a relationship of trust between the individual and their health-care provider."⁷

More extensive access to preventive care for patients who do not require hospitalization or specialist visits.

Higher satisfaction on the part of mobile and remote health care workers who are empowered by increased responsibility and accountability, a closer integration into the medical community, more extensive learning opportunities, and the increased efficiency and visibility of their work.

⁵ In Nepal, a study found that community-based health care assistance reduced neonatal death (from 36.9 to 26.2 per 1000 births) and maternal death (from 6.9 to 3.4 per 100,000 births) [Manandhar D.S. et al. (2004) Effect of a participatory intervention with women's groups on birth outcomes in Nepal: cluster-randomised controlled trial. *Lancet* 364(9438):970-9].

⁶ The World Health Organization 2008 Report quotes a study that shows that a higher reliance on primary care could avoid 50% of hospital admissions in Latin American countries.

⁷ World Health Organization (2008). Primary Health Care—Now more than ever. The World Health Report 2008.

Faster, less wasteful, more dependable health care.

"Real-time wireless broadband access to collected data, reference information, and colleagues increases the depth of expertise available at the point of care, making the patient examination more effective and reducing the need for referrals and hospitalization," according to Dr. George Margelis, Health Industry Development Manager at Intel.

A trial in rural Niger⁸ showed that a wireless link from rural health centers to the hospital to coordinate ambulance calls improved access to emergency care. Over seven years, the annual number of emergency patient transfers to hospitals increased from 59 to 352. In addition, the number of cases that could be resolved at home or at the local clinic increased from 25 to 45. All operating costs and 50% of initial capital costs were recovered within six years. The addition of real-time video communications will enable ill patients to get a preliminary assessment of their condition and use that to establish with more accuracy whether ambulance transport is warranted.

Efficient use of limited resources. In developing nations, one of the most pressing issues is the limited availability of resources. According to the World Health Organization, there are 2.3 health care workers per 1000 people in Africa, compared to 24.8 in the Americas. Furthermore, the percentage of highly trained health workers is typically lower in developing nations. The nurse-to-doctor ratio is 8:1 in Africa, versus 4:1 in the USA and Canada. The World Health Organization has identified 57 countries with an insufficient health care workforce, a shortage that totals 2.4 million health care workers (Figure 1).

Wireless broadband connections enable telemedicine applications to improve the workflow and the management of resources, and leverage existing resources to treat a larger number of patients. Many remote clinics may have equipment to perform tests, but no specialist to interpret the data. In a trial in

⁸ Bossyns, Paul et al. (2005) Unaffordable or cost-effective? Introducing an emergency referral system in rural Niger. *Tropical Medicine and International Health*. 10(9):879-887.

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Afghanistan by Roshan, a telecommunication service provider, and Cisco, remote clinics with X-ray equipment but with no resident radiologist were able to have their X-ray scans quickly interpreted by specialists at larger hospitals and promptly act on the diagnosis.

In an Intel-sponsored trial in India, “wireless voice and data communications have reduced the time to transmit select patient clinical data in a remote location, taken by a nurse and its subsequent analysis and reporting by a specialist in a tertiary care hospital, to less than 15 minutes,” according to Ashok Chandavarkar, APAC Healthcare Programs Manager at Intel. Real-time data and video connectivity will further improve the coordination and the information exchange between ambulances and hospitals.

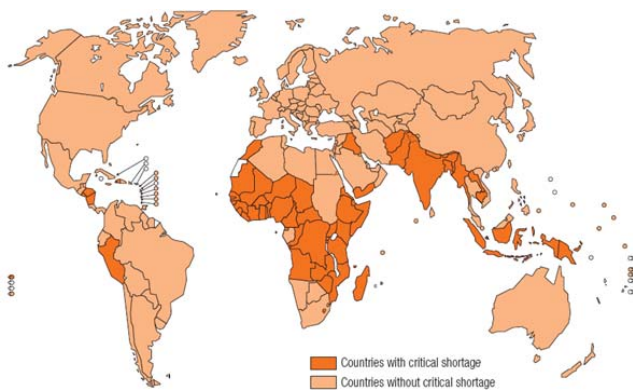


Figure 1. Countries with a critical shortage of health care workers. Source: World Health Organization. The World Health Report 2006

"Even if you have the medicine, the vaccines, and the bed nets, you need the health workers to deliver the service. With the experience of the last few years, where you have had huge global funds move into an activity to provide resources . . . we've found that the bottleneck is really the delivery," Dr. Manuel Dayrit, Director of the Department of Human Resources for Health at the World Health Organization, 2006.

Establishing priorities in rolling out WiMAX applications

Phase 1: Voice and data connectivity are “the basic requirement, to ensure that mobile workers have access to clinical decision support, patient records, and reference information,” according to Mark Blatt, Director, Healthcare Industry Solutions at Intel.

Phase 2: In dealing with patients with limited literacy, who often primarily speak a language different from the one the doctor speaks, **video applications** can dramatically improve the richness and effectiveness of the exchange⁹. Broadband connectivity also enables or enhances remote consultations with specialists.

Real-time video applications can also support e-education initiatives that encourage patients to participate via interactive formats. These videos may be hosted at clinics or accessed from home.

Phase 3: Patient-driven applications can eventually be introduced to empower patients to take a more active role in requesting care, accessing their records, and sending in data (e.g., insulin levels, blood pressure) directly to health care providers. These applications require high broadband penetration levels and extensive coordination among health care agencies, so we expect them to become available in the long term.

⁹ Jonsson, Ann-Marie and Willman, Ania (2008) Implementation of telenursing within home healthcare. *Telemedicine and e-health*, 14(10): 1057-1062.

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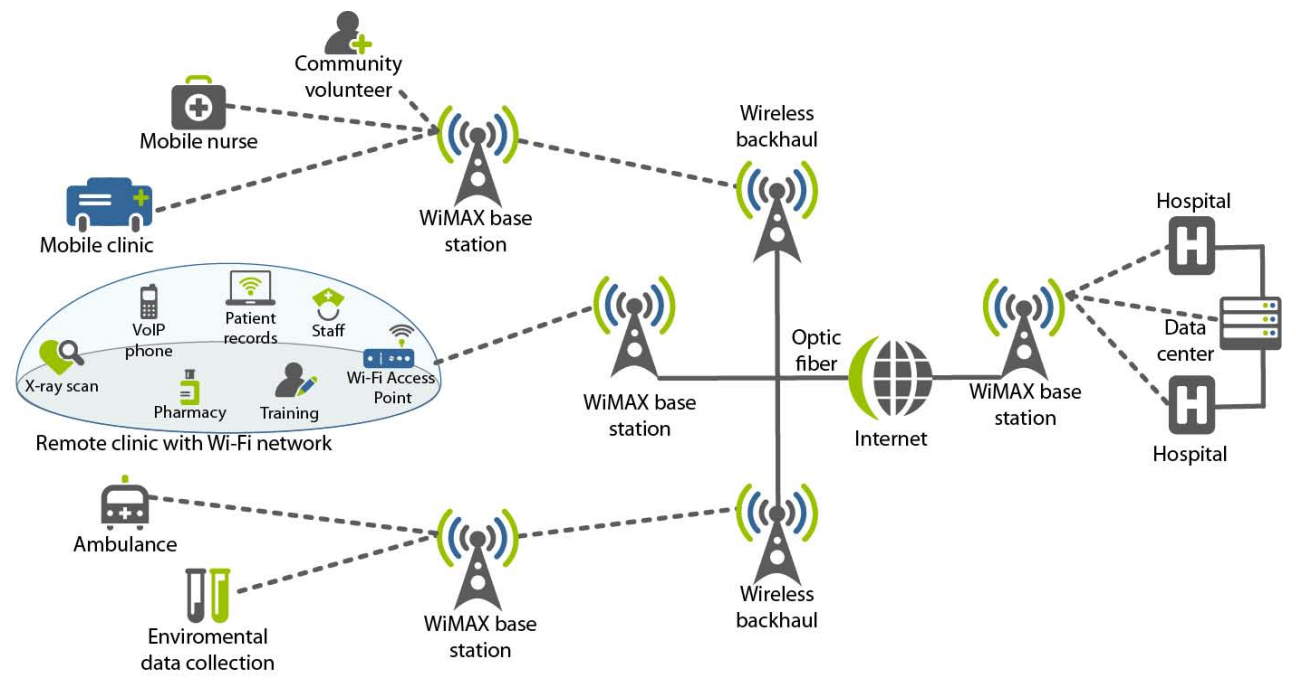
The advantages of wireless technologies

Multiple telecommunications technologies are required in order to provide the real-time availability, security, and performance that telemedicine applications need. WiMAX is well suited to providing connectivity to mobile workers and to remote and temporary clinics. Within hospitals and large clinics, Wi-Fi and WiMAX may both be used to provide connectivity to mobile devices like laptops, tablets, or VoIP phones being used by health workers at that location. Cellular and satellite technologies provide good wide-area coverage, but they are expensive and cannot support bandwidth-intensive applications such as patient imaging data uploads or remote video consultations.

The traffic from Wi-Fi and WiMAX networks may be backhauled by a wireless link, which can use WiMAX or another wireless interface, or by fiber or another type of wireline connection, if available and cost effective. Eventually, backhaul traffic is ported to a fiber optic link and to the Internet. At the other end, a hospital or a data center may receive the data and voice traffic through either a wireless or a wireline connection.

For mobile workers, a wireless broadband connection is necessary to provide real-time communications with clinics, hospitals, and data centers. Wireless connectivity may also be used at fixed locations (e.g., rural clinics) as a substitute for wireline connectivity where a wireline broadband connection is not available, is too expensive, or does not provide sufficient bandwidth.

In many developing nations, such as India, there is a trend towards deploying wireless technologies like WiMAX in lieu of expanding wireline technologies. Wireless equipment is easier to secure, is faster and cheaper to deploy, and does not require the use of copper or other material that frequently becomes the target of theft. Countries like India and Kenya, which have good countrywide fiber backbone infrastructures, are well positioned to build wireless networks with coverage extending into rural areas, because the wireless traffic from villages can be cost-effectively backhauled to data centers.



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Why WiMAX?

WiMAX is a high-performance, cost-efficient technology that is set to make wireless broadband widely available and affordable. It is particularly well suited to meet the challenges of developing nations to bridge the digital divide, to provide fixed and, increasingly, mobile access to their citizens, and to support a wide range of government, healthcare, education, and enterprise applications. WiMAX supports both mobile connectivity through laptops, tablets, netbooks, phones and other devices, and fixed connectivity through desktop modems or outdoor Customer Premises Equipment (CPE). South Korea, the USA, India, Russia, and many developing nations already have operating WiMAX networks.

Among the key benefits WiMAX brings to telemedicine are:

- **True broadband connectivity** (2–4 Mbps in the downlink, 0.5–1.5 Mbps in the uplink) to enable transfer of large data files and video applications. In cellular networks, uplink speeds are typically substantially lower, slowing down transmission from the mobile workers back to the hospital. WiMAX performance is achieved by using a new wireless interface with high spectral efficiency, and by using wider channels that can increase the overall network capacity.
- **IP-based technology**, which brings lower complexity and costs in managing the network, facilitates the development of new applications or the adaptation of existing applications, and can be easily integrated within existing networks.
- **Carrier-grade reliability and security**, due to the use of licensed spectrum and IP core network technology. WiMAX supports multiple Extensible Authentication Protocol (EAP) methods, Remote Authentication Dial In User Service (RADIUS), Diameter, Advanced Encryption System (AES), and Privacy Key Management Protocol Version 2 (PKM v2). Security is crucial to ensure protection of patient and epidemiological data.
- **Quality of Service (QoS) and traffic prioritization mechanisms**, to give priority to latency-sensitive applications such as voice and video. This increases the robustness of numerous telemedicine applications that rely on voice and video traffic.
- **Lower cost-per-bit** than cellular networks. This makes the technology affordable for network operators to deploy and for health care providers to use for telemedicine applications.
- **A wide range of devices** with WiMAX chipsets embedded along with Wi-Fi, at a very low additional cost. This gives health providers greater flexibility in choosing the best-suited devices that are within their budget.

WiMAX may initially be used mainly as a backhaul technology to provide basic data and voice connectivity to clinics. At a later stage, mobile applications will take on a larger role as network coverage, low-cost devices, and mobile telemedicine applications become available.

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Empowering health workers through training

Ongoing training is essential to motivating and empowering health care workers, and to improving the quality of care, but it is difficult and expensive to provide. Training is especially challenging for remote and mobile health care workers, who may need to take time off from work, and travel to the training location. In some cases, suitable training locations may not be available. In a trial in India, Cisco and Intel used wireless connectivity to send e-learning classes to laptops that students were able to afford thanks to government subsidies.

Many health care workers in developing nations have received limited training in school. Volunteers may have no medical background and limited literacy. Dr. Gregory Cline, Digital Health Business Development Manager at Intel in South Africa, says “Training modules have to be short (less than 20 minutes) and simple, and be accessible anytime, anywhere to be effective.”

Wireless connectivity can provide a powerful boost to training for health workers, by providing remote or home-based learning opportunities, such as:

- Access to documents that describe best-practice procedures, or that provide reference information.
- Download of presentations in slide, audio, or video format.
- Classes for credit that are managed over the Internet, with lectures, assignments, and contact with instructors through VoIP, email, or messaging.
- Real-time participation and Q&A sessions in presentations and classes using video or audio streaming.
- Training on telemedicine applications, which is a key factor in their successful long-term adoption. Dr. Cline warns that “lack of sufficient training may result in resistance to a new telemedicine application.”

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Choosing the right mobile device

The choice of mobile devices is crucial to acceptance by health workers. In nearly all cases, powerful devices are not needed, as they are used mostly for entering and viewing data, accessing the Internet, or streaming video. Dr. Cline points out that “Experience from early trials in Africa indicates that the devices should have screens of 9 inches or more to display photos and videos at the required resolution, have an effective, easy-to-use and yet powerful user interface, especially for data input, and be comfortably carried around.”

Devices like Personal Digital Assistants (PDAs) can be too small for most tasks, while health care workers may find more powerful but bigger and heavier laptops overwhelming. In many cases light laptops or netbooks are attractive solutions because health workers—and doctors especially—are already familiar with the form factor.

Devices like the Classmate PC currently being developed by Intel promise to make the familiar laptop and sub-laptop form factor affordable in developing nations. It is equipped with a camera and a detachable keyboard, and has a ruggedized but lightweight format that is well suited to health care workers.

“These devices can also be shared with others, and this raises their perceived value,” according to Debra Sloane, Global Healthcare Solutions Partner Manager at Cisco. For instance, the laptop that the nurse uses at work during the day can help her children complete their homework at night. In some countries (e.g., China, Ghana, India, Nigeria, Turkey), governments are developing or have already introduced subsidy models to encourage ownership of mobile devices, like laptops, that can be shared by family members.

In the health care environment, this enables workers to have their own device, rather than having access to a pool of devices that may or may not be reliably available. It will also make health care workers more committed to learning how to use mobile devices proficiently, and to making them essential tools in their daily tasks.

Broadband connectivity is necessary for the large files or audio/video streaming that e-training often requires. In particular, video training is much more effective than static documents or audio training in conveying rich information to volunteers or nurses whose medical training is more limited, and who may have limited familiarity with the language used by the instructor.

The Mexican government sponsored a trial to provide training to 5,000 nurses as part of their Mobile Health Workers for Community Outreach program. During the initial phase, increased worker efficiency resulted in improved patient data capture and accuracy. In further stages, the introduction of real-time, on-demand training programs requires broadband connectivity. WiMAX is ideally suited to support these training applications reliably and cost-effectively.

“The Mexico trial shows how a public and private partnership can develop a sustainable, scalable business model which brings broader, affordable access to health care services to the population,” Melitta Remington, Digital Health Group Strategic Market Development Manager EMEA at Intel, says.

Mobile health care workers also need assistance in identifying the appropriate resources to which to direct their queries (e.g., who is the best specialist to consult) or their patients (e.g., what is the best clinic or hospital to go to for a specific surgery). Peter Drury, Director, Connected Health, Emerging Markets at Cisco, says that “Wireless broadband will dramatically increase the availability and usefulness of communication tools like the Map of Medicine,¹⁰ which give health workers access to reference medical documentation and to location-specific information to assist them in identifying the relevant questions and the best course of action.”

“Improvement in the health outcomes in the rural areas is directly related to the availability of the trained resources there,” Ministry of Health and Family Welfare, India, National Rural Health Mission, 2005.

Better intelligence about the environment

Improved health care depends on timely, effective monitoring and data collection to identify the emergence of epidemic outbreaks and other health threats, monitor environmental and health trends, or simply keep track of a population’s health.

In tracking epidemic outbreaks, time is of the essence. The ability to promptly identify an outbreak makes it possible to enact preventive measures that can contain or stop an epidemic outbreak (Figure 2). Timely information can also counteract unverified information that may be circulated on the Internet.

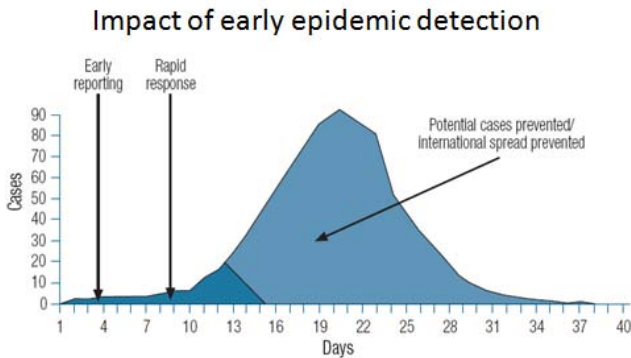
Knowledge of a threat after the epidemic has spread has limited value in containing its effects. Yet this is exactly what health officials have when data collectors need to initially record all information on paper and then transcribe it into digital format. With wireless broadband, environmental or patient information can be entered directly into databases that track population data trends. The increasing adoption of XML-based, standardized formats facilitates sharing of information among government agencies and international organizations.

Wireless connectivity also enables the collection of photographic, audio, and video data to provide increasing detail, and to facilitate further analysis. Any sample collected can be automatically linked to Global Positioning System (GPS) location-based coordinates to improve the consistency and power of data analysis.

¹⁰ <http://www.mapofmedicine.com>

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Cost of dealing with epidemic outbreaks



Figure 2. Impact of early detection in epidemics and cost of past epidemic outbreaks. Source: World Health Organization

Cisco's WiMAX Solution

- WiMAX Forum Certified
- Commercial service in five continents
- End-to-end all-IP Cisco network
- Low cost of deployment and operation
- Data, voice, and video with Quality of Service (QoS)
- Fixed, portable, and mobile service
- Adaptive Beamforming for better coverage, throughput, and building penetration
- MIMO for higher connection speed and link reliability

Governments and telecommunication regulators play an important role. “Making affordable spectrum available for wireless broadband services and awarding it to operators committed to wide deployments that reach rural communities is a critical success factor,” according to Paul Sergeant, Senior Manager, WiMAX Marketing at Cisco. For example, spectrum in the 2.5 GHz and 3.5 GHz bands is reserved in many countries for wireless broadband deployments, often targeted at underserved areas. Increasingly, lower frequencies, especially in the 700 MHz band, are also being allocated to wireless broadband services. These frequencies are especially attractive in rural deployments because lower frequency increases the area covered by a single base station, thus drastically cutting the cost of providing coverage.

Taxation and certification can also have a large impact on infrastructure rollouts. High infrastructure costs drive increases in the cost of services provided, yet many developing nations impose high tax rates and strict certification requirements on imported equipment and devices, which may double the price tag.

Taxes and certification requirements on imports are often introduced to encourage the growth of local manufacturers. However, in an industry where volume is the key to low-cost, technologically advanced equipment, protecting local manufacturers that lack scale often results in a restricted range of equipment commercially available and delays the introduction of new technologies.

Reaching cost efficiencies

Can developing nations, operating under tight financial constraints, afford to implement telemedicine applications that require wireless broadband? Currently the focus of activity is on trials to showcase the effectiveness of the applications. However, no matter how successful the trials are, wide-scale deployments have to be made affordable to become reality.

Enabling deployment of wireless broadband networks.

A crucial area where cooperation is needed is the deployment of the WiMAX infrastructure to host the telemedicine applications. WiMAX networks are being built, but the coverage is still limited in most countries. In particular, coverage in many regions has yet to be extended to rural communities.

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Leveraging wireless connectivity to improve care: what are the requirements?

The wireless connection has to support throughput speeds that can accommodate **transfers of large data files both in the uplink and the downlink**. Health care workers need to be able to transfer high-resolution photos or other data in real time so they can get feedback from doctors during examinations. Store-and-forward data transmission, in contrast, causes delays in care, and increases the likelihood of a second visit.

Privacy and security are key issues when dealing with medical and epidemiological data and patient records. Data has to be stored securely on the mobile devices, and access to the data has to be monitored. Data transmission from the mobile device to the data center has to be secured end to end with robust Authentication, Authorization, and Accounting (AAA) methods to verify the identity of the transmitting and receiving devices, to ensure they are granted the appropriate privileges, and to block unauthorized access.

The latency of the wireless link has to be sufficiently low to support **VoIP connectivity**. VoIP phones can provide affordable voice services in clinics where traditional voice connectivity is unavailable or expensive. Mobile workers often have cellular phones, but the charges for calls are often quite high. This may discourage extensive consultations among colleagues.

While data and voice services are the most immediate requirements for enabling telemedicine applications, **video connectivity** greatly enhances their value and functionality, especially with health care workers who find interactive, highly visual instruction more compelling and easier to understand. Good-quality video—in terms of resolution, frames per second, and number of dropped frames—is also needed for remote consultations. A low-resolution video may not be sufficient for a remote doctor to reach a diagnosis or for an instructor to show students how to complete a procedure or assess what they observe visually about patients' conditions.

Both clinics and mobile health care workers need **affordable connectivity**, with service plans that either are flat-fee or have large traffic allowances, to encourage frequent use of the connection. With constant use, health care workers become more comfortable with telemedicine applications, and learn to use resources more effectively.

Some telemedicine applications are time critical or sensitive to time delays (e.g., voice- and video-based applications). When there is competition from multiple applications for the same network resources, **QoS and prioritization of access** are required to ensure that time-sensitive applications have preferred access to the network. For instance, a large file upload that does not require immediate attention may be postponed or slowed down to ensure that a video call between staff in an ambulance and at the emergency room can go on without interruption.

A successful adoption of telemedicine applications among health workers requires their enthusiastic support. Without it, the risk is that the new devices will be relegated to drawers and fail to generate the needed communitywide support. If used by only a small subset of workers, most applications quickly become irrelevant, because they fail to be a gateway to resources available. **Training and ongoing support** are crucial to ensure that telemedicine applications become an integral part of health workers' daily tasks.

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New business models. “Extensive cooperation among public agencies, health care providers and operators is necessary for the creation of new business models that can address the specific needs of communities,” according to Sloane.

Wireless networks tend to be initially deployed in high-density urban areas and in suburban business areas, where their highest-paying subscribers are. Governments, health care agencies, and Non-Governmental Organizations (NGOs) need to work together with network operators to ensure that operators see a business opportunity in underserved urban and rural areas.

In some cases, governments may provide some funding towards the network deployment. Increasingly, private-public partnerships ensure long-term mutual support. For instance, government agencies may become anchor tenants by agreeing to purchase services from the operators in exchange for a commitment from the operator to build and operate the network.

To ensure long-term sustainability, it is essential to place telemedicine applications within a wider context of applications that may be related to education, training, government services, financial services, entertainment, and support for local small businesses. A single application segment, e.g., telemedicine or education, is typically not sufficient to justify a network expansion. A wide range of applications concurrently deployed by multiple public and private entities presents a stronger business case to operators assessing the opportunity to deploy their networks in underserved areas.

Conclusions

Wireless broadband technologies like WiMAX can bring reliable and secure connectivity to individual mobile health workers, and to remote and mobile clinics. They

enable a wide range of telemedicine applications that require a combination of data transfers, voice services, Internet access, and video downloads and streaming.

Broadband connectivity gives health care workers real-time access to reference material and patient records, and creates a stronger link with the wider medical community. As a result, patients get better access to health care and improved quality of care, increasingly provided right where they live. Health care workers can receive more extensive and effective training and are empowered to make treatment decisions at mobile and remote points of care, avoiding unnecessary referrals and hospitalizations. Real-time connectivity also streamlines the collection and analysis of population data, enabling earlier preventive action to contain epidemic outbreaks.

WiMAX promises to bring technologically advanced, but affordable broadband connectivity to developing nations, including underserved urban and rural areas. WiMAX will be instrumental in closing the digital divide and in achieving global competitiveness in developing nations.

“Technological advances allow WiMAX to make a more efficient use of spectrum and equipment resources than wireless technologies currently deployed,” Sergeant says. In addition to health care applications, WiMAX supports fixed and mobile broadband access and VoIP telephony to support local businesses, training, community-based and government applications, and Internet-based commerce.

To accelerate the deployment of WiMAX networks, governments, NGOs, and health care providers need to work together to establish partnerships with the operators that deploy and operate WiMAX networks. To ensure a cost-effective, affordable rollout of telemedicine applications, it is crucial that they become part of a wider ecosystem that is aimed at improving the quality of life and the economic productivity of communities and that may include fields such as education, training, and government that also stand to greatly benefit from wireless connectivity.

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Acronyms

| | | | |
|-----|---|--------|---|
| AAA | Authentication, Authorization, and Accounting | PDA | Personal Digital Assistant |
| AES | Advanced Encryption System | PKM v2 | Privacy Key Management Protocol Version 2 |
| CPE | Customer Premises Equipment | QoS | Quality of Service |
| EAP | Extensible Authentication Protocol | RADIUS | Remote Authentication Dial In User Service |
| GPS | Global Positioning System | VoIP | Voice over Internet Protocol |
| IP | Internet Protocol | WiMAX | Worldwide Interoperability for Microwave Access |
| NGO | Non-Governmental Organizations | | |

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