Unit 3

Building site infrastructure

Cover photo: A local worker helps build the new Butaro District Hospital in Rwanda
Courtesy of Adam Bacher

Unit 3

Overview

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> *"In order to improve clinical services, you need to improve (and often build) the clinic itself."*
>
> – Paul Farmer, Co-founder, Partners In Health

INTRODUCTION

Chronic lack of investment in and impoverishment of poor countries has resulted in woefully inadequate infrastructure for health care. Therefore, implementing health programs in resource-poor settings often demands significant investments in infrastructure. The term infrastructure is necessarily broad and includes public works such as power, water, and sanitation; new facilities, equipment, and technologies; and upgrades to transportation and communication systems.

While public works usually are under the purview of governments, partnerships with nongovernmental organizations (NGOs) can help link public works projects to the healthcare infrastructure. When you establish or renovate a healthcare facility, the design must take into account patient flow and infection control, as well as the need to ensure a reliable supply of water and electric power. Equipping facilities based on the medical needs of the population is critical; and given that isolation is a major challenge for healthcare providers in rural areas, providing modern information and communication technologies can do much to benefit both patient care and staff retention. Beyond these practical considerations is the importance of creating a welcoming and caring environment that is respectful of the dignity and needs of patients, families, and staff.

As you read this unit, remember that you cannot meet every infrastructure need at once. Your mission and objectives, the size and location of the site, and your resources and capacities will all help to set priorities, inform planning, and determine how you carry out your work. Programs also change over time, as you develop new services in response to the needs of the community.

1. SITE LOCATION

The location of the site will have an impact on your infrastructure needs and how you plan and implement your work. If you select the site yourself, you may be able to choose the location that best fits your organization's mission, capacities, and budget. If the healthcare program is within the public sector as part of the national health structure, the Ministry of Health (MOH) will most likely determine the best location for carrying out national health plans and strategies and filling gaps where services are limited or do not exist.

Consider the following circumstances:

- If the site is located in an urban or semi-urban area, materials, supplies, transport, and other resources are more likely to be available than in a rural setting; access for patients may also be easier.
- If the site is in a densely populated area, you may need to plan for higher patient numbers than in an area with a more dispersed population.
- If there are no other health facilities nearby, demand for services will be high.
- A site in a more remote rural area can come with unanticipated challenges. For example, you may discover that land may need to be cleared before construction can start.
- Limited water and power supplies may impede your daily operations and must be accounted for in your planning.

1.1 *Accessibility*

Can patients access the site easily? Public transportation in resource-poor settings, particularly in rural areas, may be sparse and inconsistent, which can often limit patient access to healthcare facilities. Look at the population in your catchment area and try to estimate how far away from the site people live and how long it will take to get there. Locating other health services in neighboring areas on a map can also give you an idea of the expected patient load.

Think about day-to-day operations and construction work. Close access to local markets and commercial activities can reduce costs and prevent stock-outs and delays in receiving foodstuffs, fuel, and other essential items. The distance from the closest airport and seaport will influence the delivery time and transport costs for supplies and equipment from other countries. Knowing the quality of the country's roads as well as the ratio of roads to the country's total area can give you an idea of how easy or challenging transportation will be.

PIH NOTE

Our model of community-based care recognizes that we may not be able to reach all potential patients who can be served by the health facilities at the site; this is where community health workers (CHWs) play a critical role. They live in the communities we serve and make home visits to provide care to patients, including those who live along the periphery of the catchment area.

1.2 *Topography and climate*

Seasonal changes can create problems for patients traveling to the site, and at certain times of year you may encounter a drop in patient numbers as well as difficulties in providing some essential services. If the site is in an area that has a rainy season, many roads, particularly those in rural areas in resource-poor settings, can become impassable. Flooding of nearby rivers or streams can also keep patients from visiting the site. Working with local authorities and the community to make small improvements, such as emergency repairs on muddy patches, can help improve access.

Weather will also affect the timing and types of construction. In areas with heavy rainfall, land erosion can be a problem. Roofing may need to be reinforced in climates with heavy snow. In both warm and cold climates, temperature control and ventilation must be considered in the design and construction process. Unexpected situations can arise at any stage of the process; anticipating problems can help keep operations continuing efficiently.

Figure 1: Patients keep dry at an outpatient clinic at Neno District Hospital, Malawi, during the rainy season
Photo: Craig Bender

PIH NOTE

We had just finished constructing 22 staff housing units at the site in Malawi when we experienced the first major storm with heavy rains. The land started to erode very quickly after the storm, and serious damage to the houses that sat above or below the unprotected ground was a real possibility. We had to act fast, hiring a local contractor and his team of laborers who built large stone retaining walls to protect the land from washing away. The workers also dug drainage outlets around the roads. Our next step was to plant grass, shrubs, and trees to further protect the land against erosion. We learned the hard way, but the experience made us better prepared for the next rainy season.

2. CONSTRUCTION PROCESS

Many tasks in the construction process for major infrastructure projects can demand a level of technical expertise that you may not have. However, your contacts with local officials, community leaders, and other partners in the area and farther afield can help you identify people with relevant skills and experience. A program manager can raise more general issues and seek to ensure that the construction process is robust yet flexible enough to deal with unanticipated problems that may arise.

2.1. *Assessment*

The first important step in improving or developing new infrastructure at the site is to assess what work needs to be done. The size of the site will be your starting point, but specific infrastructure needs, including sewage, electricity, and water, must also be identified. An initial site assessment can aid planning and help avoid costly changes and unnecessary delays in providing services.

TIP: *Immediate improvements in infrastructure at the site are likely to bring about a rapid increase in patient numbers.*

Wherever possible, the assessment team should include people with technical and medical expertise and should cover categories including:

- Number, size, and uses of buildings
- General condition: overall structure, roofing, walls, flooring, paint, ventilation/temperature control, drainage/erosion control features
- Waiting areas
- Grounds around the buildings (gardens, storage, other structures)
- Guard/security area
- Morgue
- Electricity (sources, wiring, lighting)
- Water (sources, storage, plumbing)
- Sanitation (septic systems, latrines)
- Medical waste disposal capability
- Communications infrastructure (telephones, Internet connectivity)
- Areas for preparing, serving, and storing food
- Laundry
- Road access

PIH NOTE

In our first assessment of Manamaneng clinic in Lesotho, we traveled by road to see how accessible the site was and to identify infrastructure needs. The site is about 260 kilometers from Maseru, the capital, with some 80 kilometers of the road unpaved. We noted that the few small streams that cut across the unpaved parts could easily hamper travel after heavy rains. Infrastructure at the site turned out to be the least developed of all the sites where we worked in Lesotho. Staff housing was a big challenge, as there was only one communal room where staff slept. Inadequate accommodations for staff would slow down the deployment of a much-needed clinical support team, so we planned to use a trailer to improve accommodations in the short term and later designate it as space for counseling and testing people for HIV. The good news was that the compound was large, so that we would be able to construct additional facilities.

2.2 *Work plan and priorities*

The work plan is an ongoing process involving collaboration with local government and health officials, technical experts, and the local community. The preliminary plan should be informed by the knowledge gained from studying the epidemiology and demographics of the community as described in *Unit 1: Learning about the local context*, so that you have a good idea of the population you will be serving. The programs and services you intend to deliver and potential patient numbers in your catchment area will also help determine what facilities will be needed. Finally, the results of your assessment will affect your priorities. For example, if the site has some infrastructure, provides some services, and has limited power and water, your priority may be to enlarge existing space before expanding the power and water supply. However, providing power or water may be a priority for sites completely lacking these services. In any case, it is important to consider what is needed to become operational so that you can start providing health care to the local population as soon as possible.

PIH NOTE

When we arrived at the site in Malawi, all that existed was a hospital in need of repair near a cornfield. We were eager to renovate the hospital quickly so that we could start providing health services as soon as possible. We also needed to build housing for staff, so we embarked on both projects simultaneously. We implemented the two large infrastructure projects while we were also establishing our programs and learning more about the local community. We had not yet set up communications, so with no Internet and only local cell phone connections, contact with the PIH Boston office and with family and friends outside of the district was limited. Looking back, although we did begin to deliver and increase health services quickly, our staff also experienced many stressful moments during that time.

2.3 *Norms or standards*

In developing a preliminary work plan, be sure to check with the appropriate government ministry or agency, such as the Ministry of Planning, the Ministry of Public Works/ Infrastructure, or a unit in the MOH, for norms or standards regarding the design of health facilities and other infrastructure systems. Norms can exist for what constitutes a specific health facility, such as a health center or a hospital, in terms of the services provided and population served. Standards can also exist that specify designs, types of equipment, and materials and dimensions for particular buildings. For example, Malawi has set standards for a hospital requiring operating rooms to have their own laundry facilities. In some cases, there may be specific requirements about zoning and land ownership that must be met before construction can take place.

Although it may take time to become well versed in these standards or norms, knowing them before starting to build or renovate will help save time, money, and effort. If design standards are difficult to obtain, are outdated, or are inappropriate for the number of patients you plan to treat in the facilities, you may have to develop your own site plan, but it is always important to consult with government agencies first.

2.4 *Local services and expertise*

Figure 2: Locally hired staff construct the Butaro District Hospital in Rwanda

PIH uses architects and engineers for design, structural assessments, and precise material specifications, and relies on qualified electricians and information technology (IT) experts for major work. While this assistance can incur additional costs, in the long run it helps to ensure the structural integrity of buildings and major infrastructure projects and it supports good business practices. Some national standards may mandate the use of architects, engineers, and other specialists in the construction process. Hiring local people and collaborating with local officials on the construction plan and its implementation builds trust and a sense of partnership with the community and can encourage people to use the health services you provide.

PIH NOTE

We rely on teams of skilled workers for our construction projects at the site in Rwanda—local people whom we know and who know us. For the smaller jobs, we use our own crews—people who have been trained in our workshops to become painters, masons, carpenters, and other skilled workers as part of the Program on Social and Economic Rights. For the larger work, the crews join with a contractor, a site engineer, and foremen, but we also hire an outside consultant to monitor the inventory of materials, quality of materials, and the quality of the work. Although this step may take additional time, we learned that it prevents mistakes and allows us to construct structurally sound buildings for the long term.

2.5 *Costs*

With expert assistance on board and the priority work identified, the next step is developing a budget. Remember to distinguish between one-time initial costs, such as the architect's design, and ongoing operational costs, such as building maintenance. Also factor in costs for staff and for transport and delivery of equipment and materials. Account for delays in delivery or changes in plans and for any needed additional training and longer-term support.

As with any collaborative process, you may find that the construction plan goes through more than one readjustment during your discussions with officials, members of the community, and contractors. To ensure that the mission and objectives of your organization are addressed in the plan, keep revisiting them as the process unfolds. When the plan is complete, approval from government agencies, including the MOH, may be required at both the district and the national level.

2.6 *The tender process*

Some countries, such as Rwanda, have national regulations regarding submission of tenders (bids) for the work, based on the cost of the project and who is funding it. Funding agencies may also have their own procedures for tenders for large projects, specifying the number of bids received and the length of time allotted to receive bids. These details are usually included in the funding agreements made with the agencies. Whenever possible, PIH obtains three bids for the work. This practice is a useful internal control that helps to ensure transparency and independence when we select bids. (See *Unit 8: Establishing a financial system* for how the tender process relates to the financial system.) If an official tender process is not in place, you may want to develop your own and apply it to all of your major projects. Items to include in the tender include:

- A clear description of technical requirements and services the contractor will provide
- Timelines for the work
- Provisions for use of local labor and materials
- Charges for transport and delivery of equipment/materials
- Coverage for any delays or changes
- Provision of warranties
- Provision of training and maintenance support, if relevant

TIP: *When drawing up your document to solicit bids for construction work, include a retention clause in the payment schedule to provide some leverage in assuring quality work and to have money available to resolve unanticipated problems.*

You can solicit bids from contractors recommended by partners and local officials or publicize the tenders in the local press, or both. Developing criteria before you review bids can help determine which requirements are most important. For example, PIH respects the local minimum wage in its payments to local workers. The lowest bid would not be accepted if it were connected with their exploitation.

Once you have selected the bidder, you can use a local lawyer to draw up a contract for substantial work. The contract should cover the scope of work in detail, specific responsibilities, due dates, and mode of payment. (See *Unit 2: Understanding legal matters* for more on how a local lawyer can help.)

2.7 *Construction work*

Hiring a Clerk of Works helps to ensure the quality and integrity of the work. The person in this role monitors construction, tracking work and cost projections. He or she checks that work is carried out in the correct order, such as ensuring that foundations are laid before equipment is delivered. The Clerk of Works checks supplies daily to avoid delays

and is also the main contact with contractors. The job entails noting possible problems or bottlenecks in advance and resolving them with contractors and suppliers. This person can also clarify responsibilities and work schedules among several contractors that may be working on the same project.

TIP: *Invite local officials and community leaders to visit the site, both during construction and once the work is completed. Their engagement helps to strengthen future collaboration.*

2.8 *Training and maintenance*

Training should be included in the tender. At least one staff member should receive basic training in how to manage processes and look after equipment. Documentation should also be provided in the local language whenever possible. Additional technical skills may be required for maintenance work, and you will need to identify where you can obtain them, ideally from a local provider. You will also have to establish a maintenance plan for your new facility. Having checked conditions of warranties in the tendering process, you should also know how you can get repair service off site and ensure that you have sufficient spare parts and other supplies on site.

3. DESIGN CONSIDERATIONS

The site design will depend on the services provided, the size and condition of the land the facilities occupy, and the population being served. It may be difficult to accurately determine current and future patient numbers during the design phase, but it is worth making an informed estimate; once facilities have been built, you can quickly run out of space for accommodating an increase in patient load.

3.1 *Overall design and layout*

Designing attractive and welcoming facilities that are easy to navigate sends an important message to patients, visitors, and staff that they are valued and that they will be treated with dignity and respect. “Dignification” of the facility and the grounds does not have to be an expensive endeavor, but does require planning and upkeep. Landscaping the site’s grounds with plants, flowers, and shrubs; building simple children’s play areas; and keeping the grounds clear of trash and clearing nearby fields of brush and refuse incur little additional cost, help to boost morale, and make a positive first impression about the quality of care being offered. Clear, accurate, and uniform signage around the facilities in the local language also shows respect for the people you are serving. Inside the facility, a fresh coat of paint and simple decorations can brighten rooms and improve the ambience.

Figure 3: Gardens on the grounds of Rwinkwavu District Hospital in Rwanda

Figure 4: Children play on the clinic grounds in Lesotho

3.2 *Patient flow*

Deciding how to move people around the facility without creating opportunities for spreading infection is paramount when laying out the location of functional areas. Think about patient flow as you address the following questions:

- How can you design your space to avoid a crowd of people waiting outside a single door to enter?
- How can you avoid having patients who are infectious in close proximity to those who are not infectious in a waiting area?
- How do you maintain quiet and calm in examination areas, keeping them separate from the noise and congestion of the waiting areas? How do you accommodate a crowd waiting at an indoor pharmacy or for blood tests?
- How can you make the facilities accessible to those who might need to be carried into the facility or have difficulty using stairs?

PIH NOTE

The design of Lisungwi Hospital in Malawi is a good example of how the goals of good patient flow and infection control influenced the layout. We designed the hospital around a central courtyard with waiting areas mainly outside so that the patient flow went around the building. This design, reinforced with clear navigation paths and signage, avoided creating highly congested indoor areas and hallways.

3.3 *Infection control*

Effective infection control measures keep airborne germs from spreading in hospitals, clinics, and other buildings. Infection control is a particular concern for medical facilities, where people with HIV/AIDS and others who may have compromised immunity are treated. HIV-infected people are approximately 100 times more likely to contract tuberculosis (TB)

than non-HIV infected people; because of this vulnerability, it is especially critical to prevent the spread of drug-resistant TB among those who have HIV.[1]

Controlling the spread of airborne infections requires adequate ventilation, accessible and adequate sanitation, and an appropriate layout of services. Staff must be trained in correct infection control practices, and safety measures for both staff and patients should be in place. Guidelines for implementing effective infection control when upgrading or constructing new buildings include:

- Provide open space for triaging patients.
- Designate separate spaces for coughers and non-coughers, whenever possible.
- Create outside pathways to the extent possible. Remember to include an outside pathway to the pharmacy's dispensing window.
- Avoid creating congested areas.
- Eliminate indoor corridors to the extent possible.
- Construct open courtyards to the extent possible.
- Construct buildings with high ceilings for good ventilation.
- Install wide, easy-to-open windows. Place windows on opposite walls to keep air circulating.
- Provide separate patient wards or rooms with good ventilation for inpatients with TB.
- Install mechanical ventilation, such as basic fans.
- Install ultraviolet germicidal irradiation (UVGI) lamps on ceilings or walls. These lamps resemble fluorescent light and disinfect the air in the upper part of the room. The cleaned air then mixes with the air in the lower part of the room and dilutes any viruses or bacteria that remain.

4. BUILDINGS AND FUNCTIONAL AREAS

It is important to consult with clinicians and other relevant staff when drawing up and implementing plans for buildings and functional areas. These discussions will help to ensure that your facilities are appropriately designed and will enable you to determine what equipment is needed for particular functional areas. In obtaining equipment, you will need to check for government standards or norms. Local health officials and staff at other NGOs in the area may help you find out what is available locally; if certain machines are not available, they may have to be imported. When purchasing specialized equipment, be sure to inquire whether a special license is needed and whether training and maintenance are available. (For more details on purchasing and importing equipment and supplies, see *Unit 4: Managing a procurement system*.)

At first, you will probably not be able to include in your plans all of the facilities that are described below, but you may want to consider them as your capacity grows. Most of these areas will require power for lighting and for operating equipment, and some will need refrigeration. Also think about storage space, along with seating for patients, caregivers, and staff.

[1] Rich, M. (ed.). (2003). *The PIH guide to the medical management of multidrug-resistant tuberculosis.* Boston, MA: Partners In Health. Retrieved online at: *http://www.pih.org/publications/entry/pih-guide-to-the-medical-management-of-multidrug-resistant tuberculosis.*

4.1 *Urgent care area*

This area, where emergency patients can be seen quickly, should be easily accessible from the front of the facility and is usually supplied with a stretcher or a wheelchair, as well as an examination bed. While some urgent cases can be treated at the health center, those requiring complex surgical interventions or other specialized treatments are more likely to be transferred to hospitals or other tertiary care centers.

4.2 *Waiting areas/areas for recording clinical information and taking vital signs*

Provide covered, comfortable waiting spaces with seating for patients and caregivers. In warm or temperate climates, these areas should be outdoors. Wherever possible, designate a separate waiting space for patients with highly communicable infections, such as TB, to encourage proper infection control. To facilitate patient intake and triage, establish a prominent area where patients have their first point of contact with staff. Remember to allow enough space for the patient and staff to interact.

Figure 5: Patients wait for care outside the Zanmi Lasante clinic in Lacolline, Haiti

4.3 *Consultations*

General consulting and examining rooms should be designed to accommodate the needs of your clinical programs. Consider having separate spaces if you provide programs with different requirements, such as one serving mothers and children and another for testing and counseling for infectious diseases like HIV.

4.4 *Pharmacy*

Check whether there is an adequate waiting area—ideally outside and shaded in warm climates—to accommodate patients waiting to receive medicines at the dispensary. If you plan to use the pharmacy as the main stock area for your medicines and other medical and surgical consumables, the storage should be separated from the dispensing area. If not, a pharmacy can be little more than a room with a door that locks, ample shelf space, and a window through which medicines can be dispensed. Remember

Figure 6: Women pick up prescriptions at a PIH-supported pharmacy in Lesotho

to provide adequate refrigeration for medicines that require temperature control and to raise the shelving off the ground to guard against infestation and flooding. A system for organizing medicines is also critical.

If the pharmacy will house a sizable amount of stock, provide adequate space for both incoming and outgoing stock and ample work space for sorting and repackaging stock. If you plan to develop a computerized stock management system, you will also need adequate space for housing computing equipment. (For more details on the PIH electronic stock management system, see *Unit 4: Managing a procurement system*.)

4.5 *Phlebotomy room*

You may want to set up a specific room or designate an area for phlebotomy, which will require reliable lighting, storage for sterile supplies, and a mounted container for sharps disposal.

4.6 *Laboratory*

Check whether there are up-to-date national guidelines for designing and outfitting laboratories; if there is a national reference laboratory, staff there may be able to help, especially if printed copies of the guidelines are difficult to obtain. The size of the laboratory will depend on what you intend to do in this space: in addition to carrying out the actual testing, will you also store supplies and load and unload deliveries? For testing, you will need to have running water, temperature control, and refrigeration. The equipment and supplies for testing will depend on the clinical services you provide, national protocols for diagnosis and treatment of specific diseases, and your budget and service capacity.

Figure 7: A technician working in a PIH-supported laboratory in Tomsk, Russia

PIH NOTE

We generally begin by equipping the laboratories with reagents, centrifuges, and microscopes. At most of the sites, we also provide CD4 machines that measure the functioning CD4 cells in the body and, correspondingly, the health of the immune system to fight HIV infection. These machines are fragile and require air conditioning.

4.7 *Radiology*

A stationary x-ray machine is big and bulky and you will need ample space to house it, as well as equipment to transport it if you are in a remote rural area. The radiology room's walls must be quite thick to prevent radiation leakage and the floors strong enough to withstand heavy equipment. Because these fixed units are very large and have multiple components, portable units can be viable alternatives and are comparable in terms of power and image resolution. These units are about 1.5 to 1.8 meters tall and are still fairly heavy, so they are not easily moved.

PIH NOTE

When PIH's new x-ray machine arrived at the renovated hospital in Lesotho, it would not fit through the door of the room where it was to be housed. To install the machine, we had to remove a section of the wall and install a large door. After that experience, the team knew to check space requirements for equipment prior to its arrival.

In many countries these portable units are placed on trolleys and wheeled from room to room to accommodate bedridden patients, but at PIH-supported sites they are used as if they were fixed. You may be able to obtain an older portable or fixed unit through a donation, because many health facilities in high income countries are switching over to digital imaging systems. In resource-poor countries, digital systems are still expensive to buy and ship if not locally available and are often difficult to maintain.

TIP: *If the x-ray facility will be heavily used, an outdoor waiting area can help limit congestion.*

4.8 *Ward space*

The number and organization of beds will depend on whether you are outfitting and building a health center or a hospital. For a health center, consider providing limited space for inpatient services related to short-term needs such as uncomplicated births, cases of extremely high fever, and observation of patients before treatment or referral to the hospital or another facility.

For a hospital, the number of beds provided will depend on the catchment area's population, burden of disease, and existing MOH norms or standards. You may want to plan separate wards for men, women, and children, as well as a maternity ward. There should also be separate isolation rooms for patients with infectious diseases like TB. The wards will need manually adjustable beds, as well as room-dividing screens, ventilation, and temperature control. Nurses' stations should be located near the wards. To encourage good infection control practices among staff and patients, handwashing stations or sanitizers are best placed near the wards. Sanitation facilities for patients and staff should also be provided nearby.

4.9 *Operating room for basic surgery and emergency obstetrics*

Providing surgical care in resource-poor settings is a complex endeavor, so most health centers and clinics focusing on primary care do not include surgical care in their range of services, at least initially. It is important to plan carefully before proceeding with this service. If your area has a need for surgical care that cannot be addressed at the regional or district level, start by preparing your facility for emergency surgery only, such as cesarean sections or trauma cases. Consider building a procedure room to enable doctors to perform cesarean sections and other emergency procedures.

Figure 8: Clinicians deliver a baby in the operating room at Zanmi Lasante in Haiti

For a district hospital, two operating rooms are ideal: one for emergencies (usually obstetric) and another for elective surgery. Allocate enough space for staff preparation and patient pre- and postoperative care, with a separate space for newborns. The rooms should be outfitted with proper lighting and basic equipment, including operating and delivery tables, anesthesia machines, suction machines, surgical procedure kits, patient monitors, and sterilization equipment. Surgical suites require uninterrupted electricity and good temperature control, both of which are challenging to provide in resource-poor settings where power supplies can be erratic or nonexistent. Additional power from generators or battery-operated equipment should be available.

4.10 *Morgues*

Sufficient space for a morgue is often allocated within a hospital building. However, if the hospital is small and space is limited, you may need to find space near the facility or identify the nearest hospital that has a morgue. Smaller health centers typically do not have morgues, in which case, bodies are usually returned to families. In disaster situations, when temporary morgues may be required, you will need to convert space in the hospital or in other buildings at the site. In addition to space, materials including sheets and containers are required for storing bodies, and electricity and refrigeration are required for preserving them. It is advisable to consult with the appropriate government authorities (the MOH, Ministry of Justice, local mayor) about laws or health codes that may pertain to handling or disposing of bodies, performing autopsies, and record keeping. Also be aware of cultural and/or religious practices regarding death and the management of dead bodies.

4.11 *Social workers' area*

Social workers need an area for conducting confidential discussions with patients and caregivers, and for meetings with other staff.

PIH NOTE

Social workers are an important part of our staff at the sites. They visit patients at home and collaborate with clinicians and CHWs, working to ensure that socioeconomic obstacles do not prevent patients from accessing health care or adhering to their treatments.

4.12 *Training space*

Depending on your budget, staff, and long-term objectives, you may want to designate a training area at the site. This space can range from one small room to a dedicated facility. Regardless of the size, try to provide furniture that can be moved to support different training activities. If the training area has a reliable electricity supply, take into account what electronic equipment you will be able to provide, such as a television, projector, screen, and a DVD or videocassette player. If you will be training people from other locations, you may need to provide sleeping accommodations and cooking facilities.

4.13 *Archives and data records room*

Patient records must be housed in a secure area to maintain confidentiality, but they must also be accessible and easily retrievable by staff. If records are kept electronically, computers and peripherals will be required. These requirements are covered in *Section 7, Electricity supply* in this unit.

4.14 *Storage area/warehouse*

When you begin work, a purpose-built warehouse may not be needed. However, you will have to allocate some space for storing medical and nonmedical supplies and food. The space should be sturdy enough to protect stock from inclement weather, insects or rodents, and unauthorized entry. The door should lock, and the building should have a roof in good condition, solid walls, and a floor that stays dry during rainy seasons. You may also need to provide temperature control and secure access for loading and unloading. As your programs grow, you will probably need additional space for storing items including office supplies and furnishings, medical equipment, tools, and spare parts. Flammable materials such as gasoline or propane should be stored in a separate area. If you plan to manage an electronic inventory, you will also need adequate space for computing equipment.

TIP: *Be sure to have a safety plan in place and fire extinguishers accessible in all your storage areas.*

4.15 *Sanitation facilities*

The most appropriate sanitary system is the one that will best suit the site's environment. Flush toilets with septic systems are a common option in rural areas, but they are dependent on a piped water supply. The cost per person is higher than for a system of latrines, and maintenance is required. Septic tanks have to be pumped out every few years, with care taken to avoid environmental damage. Latrines, both compost and traditional, are cheaper to construct and are most commonly used in areas where water supply is limited. They need to be dug out periodically. Some characteristics of different sanitary systems are as follows:

A septic system is essentially a sewage disposal system linked to flushed toilets. Its basic elements are an underground holding tank fitted with an inlet, outlet, slotted walls, an access hole on top, and a leaching or draining field. Wastewater is flushed into the tank, where the solids settle to the bottom and where bacteria in the tank help break down some of the solids. The liquid effluent flows out of the tank into a draining field consisting of a series of parallel, underground, perforated pipes that allow wastewater to percolate into the surrounding soil, which is where the wastewater treatment actually occurs.

Through various physical and biological processes, most bacteria and viruses and some nutrients in wastewater are consumed as the effluent travels through the soil layers. The system allows water from the draining field to percolate into the underlying soil layers and potentially into groundwater. To avoid contaminating groundwater, discharged wastes, such as solvents and chemicals, need to be controlled (see *Section 6, Water supply* in this unit for more details on water quality). Septic tanks need to be cleared of sludge to prevent clogged draining fields, and the draining fields must be properly sited.

Sewer systems are linked to flush toilets and transport effluent to treatment or disposal points. These systems are not often seen in rural or resource-poor settings where the required infrastructure and appropriate disposal points are lacking. If the health facility is sited in an area where a sewage system already exists, it is worth investigating how your site could be connected to it.

Latrines store fecal matter that is left to decompose. Latrines are inexpensive and easy to construct, but they may not be suitable for large numbers of users. With composting latrines, the fecal matter collects in a vault or box and is mixed regularly with organic material such as earth, wood, or ash to deodorize and control the moisture content. The accumulated waste is left for a minimum of a year in order to ensure that all harmful organisms have died off and the material is safe to handle. Health risks have been associated with improperly managed composting latrines, and handling human excreta may not be acceptable in some countries and cultures. However, in some settings, composting latrines have advantages over flush toilets and septic systems:

- They do not use water, leaving more water available for drinking and washing.
- Construction is simple, as there is no need for soil absorption systems.
- Once health risks have been minimized, natural fertilizer, a byproduct of the composting process, can be used to improve the site's landscaping or farming.

PIH NOTE

When we first began work at Zanmi Lasante, our sister organization in Haiti, the latrines we built in Cange were sufficient, but they quickly proved to be a disaster when patient traffic increased to over 400 people per day. The latrines could not handle the volume of waste, and the smell became extremely unpleasant. The infrastructure staff assessed the situation and determined what funds were needed to install a modern sanitation system. These were discussed with Zanmi Lasante's Executive Committee and although the costs were not insubstantial, the Committee agreed that an upgrade was sorely needed. With the budget approved, we were able to build ten flush toilets.

4.16 *Medical waste disposal facilities*

Biohazardous waste includes blood and blood products; pathological waste, such as body fluids, tissues, organs, and body parts; microbiological wastes containing or contaminated with infectious agents, such as discarded specimen cultures and live or attenuated viruses; sharps waste; and animal waste. Hazardous waste includes radioactive material or hazardous chemicals. Poor management of either biohazardous or hazardous wastes can expose healthcare workers, waste handlers, and the community to toxins and toxicants that can cause illness and injury. Find out whether government standards or guidelines exist for disposing of biohazard and hazardous waste. Managing the disposal process will depend on the quantities and types of waste produced on a daily and weekly basis. The waste should be collected at its source and ideally stored in metal or plastic (reusable) containers or baskets with liners big and thick enough to hold the specific waste materials. To avoid accumulation and decomposition, the waste should be collected regularly and stored in an area limited to authorized staff before its final disposal.

In many developing countries, incinerators are commonly used for the final disposal, and environmental regulations or guidelines may exist for their use. There is a variety of incinerators to choose from, ranging from prefabricated metal ones to incinerators made from bricks that can withstand high temperatures. Some types may be locally available. Regardless of type, incinerators should be in a fenced-off area, located away from people.

Figure 9: Local staff construct an incinerator at Zanmi Lasante in Haiti

PIH NOTE

In the early days of our work at Zanmi Lasante in Haiti, we wanted to build an incinerator to dispose of waste at the site, but we needed to build on land away from the main working area. We found a suitable piece of land owned by the Haitian government. Their officials knew that we were committed to working with them, so they gave us the green light to build the incinerator. However, it was at the local level that we actually had to procure the land on which to build. Our first stop was the mayor's office in Cange. The mayor knew that PIH had an agreement with the government to build a health facility and the sanitation systems that it required, so the negotiations to acquire the land proceeded very quickly and we were soon able to build the incinerator on it. Since then, we have gone to the mayor's office every time we needed land for incinerators at each of the other eleven sites in Haiti.

4.17 *Cooking facilities*

Decide whether you will be providing meals for staff, patients, or visitors. If you have a small staff and few inpatients, you might decide to construct a minimal space with appliances for staff and caregivers to store foodstuffs for meals. At PIH-supported sites, food is provided for patients to ensure that they receive a nourishing meal and to alleviate unnecessary burdens on a family member to be at the site daily, leaving other family members at home unattended. If you do construct a kitchen, think about ventilation and whether running water and refrigeration will be available. While propane gas for cooking stoves can be very expensive, particularly if large quantities are needed, alternatives such as charcoal are much more environmentally damaging. It is worth investigating options for energy-efficient stoves, including solar-powered ones, which may be available locally.

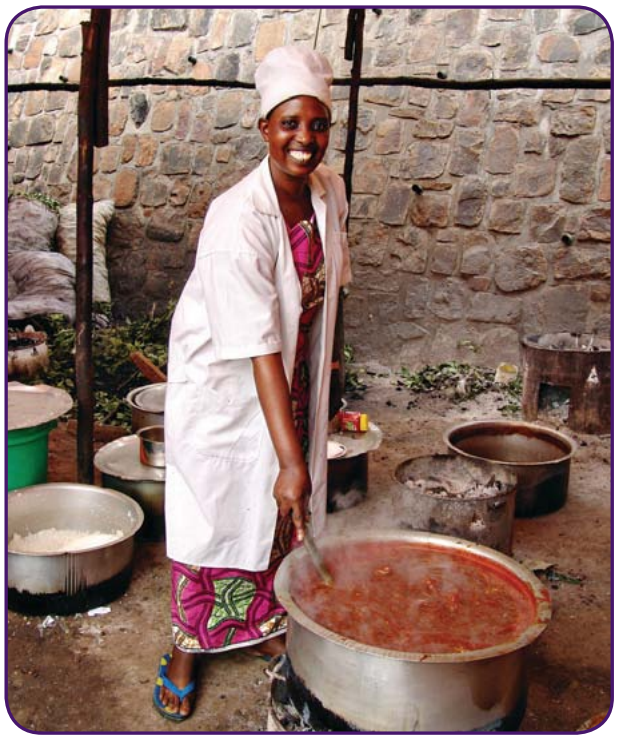

Figure 10: A cook prepares food for patients at a PIH-supported site in Rwanda
Photo: Laurie Wen

TIP: *Building a "grease trap," a buried concrete grease box in the kitchen, helps to improve the lifetime of the septic system by reducing the amount of oils and grease that flow through it.*

If an indoor kitchen is not possible or is inadequate, ensure that there is a designated place for cooking outside, away from places where people congregate and outfitted with equipment for outdoor cooking. In your plan, remember to allow for the site's expansion and accompanying increases in patients and staff.

4.18 *Laundry facilities*

When allocating space for washing linen and laundry, think about where the water supply is located and how staff will access it. This area will probably be outside, but in rainy seasons an indoor drying area may also be needed. In tropical climates, ventilation is particularly important.

4.19 *Staff housing*

While it is practical and convenient for staff to live near a health facility, housing is not always available. In remote rural areas, the absence of staff housing can act as a barrier to recruitment. Find out if rental housing is available and seek guidance from local government and health officials. If staff will be living away from the site for periods of time, determine work schedules to accommodate this circumstance.

If you plan to build or renovate staff housing, check with local authorities for any regulations pertaining to the construction; be aware that in some countries, the government decides which levels of staff have priority for housing. When drawing up a design, consider the most appropriate one for your staff needs: dormitory-type housing, single housing, or multiple occupancy—each has different requirements. Remember to consider the location of the water supply when planning the sanitation facilities and plan for how you will provide power.

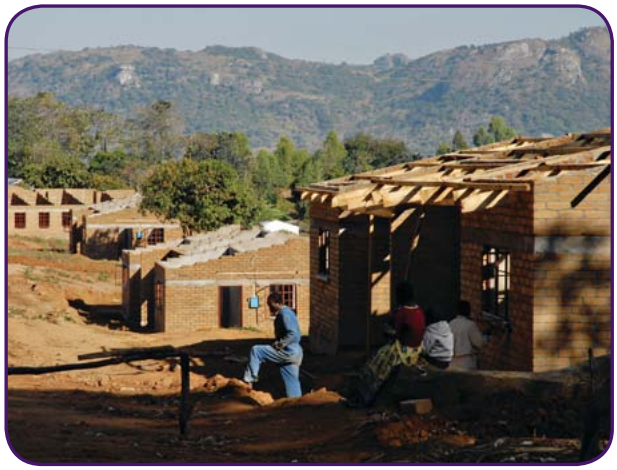

Figure 11: Constructing staff housing in Malawi
Photo: Jamil Simon

5. TRANSPORTATION

Transportation is an important consideration in your planning process. If you are working in a health center, you will probably be transporting critically ill patients to hospitals for emergency or tertiary care. Patients may also require transportation to receive services not available at the closest facility, such as x-rays and laboratory tests. If the site is located in a remote rural area, staff may also need vehicles to visit patients who cannot travel to the health facility. Transportation may be required to ferry staff to meetings with local officials and other health providers and to off-site housing. In addition to transporting visitors, you may need to transport equipment, medical and nonmedical supplies, foodstuffs, and samples/specimens.

5.1 *Vehicles and other means of travel*

Find out whether there are norms or standards for vehicles used to transport patients. If you purchase a vehicle, consider your budget as well as the site's location and local weather conditions. Even when roads are not cut off by rains or storms, travel on poorly maintained roads can be dangerous and can lead to frequent breakdowns—the wear and tear on even the hardiest vehicles can be significant. For transporting patients and staff, you may want to purchase all-terrain vehicles that can accommodate several people.

Figure 12: Haiti's roads cause frequent wear and tear on vehicles

If you are working in a hospital, find out what kind of transportation, including ambulances, is available to meet the needs of the surrounding health facilities. If your health facility is some distance away from the nearest hospital and you have the budget, you may want to buy an ambulance or equip a large, sturdy vehicle with some basic medical equipment and space for patients. (For more details on purchasing vehicles, see *Unit 4: Managing a procurement system*.)

If any of these vehicles must be imported, remember to calculate the time and costs of clearing them through customs, and include packages of spare parts in the initial order. Operating costs can be high if fuel and parts for maintenance are not easily obtainable, and it may be helpful to purchase quantities of vehicle supplies such as tires, filters, and oil. Consider having a maintenance plan and staff who will be able to follow up with repairs and servicing.

Keep in mind that if the site is located in a remote rural part of the country, you may need to rely on other modes of transportation. Motorcycles can improve staff access to patients living in more remote areas. Riders will need some training, as well as helmets and protective clothing. Many countries also require specific motorcycle licenses. If the terrain is not too mountainous, bicycles are another less expensive option for reducing travel time.

Figure 13: A village health worker travels by motorcycle to reach patients in Lesotho

5.2 *Transportation guidelines*

It will be helpful to determine the criteria under which patients qualify for transportation assistance, particularly if you are serving a fairly dispersed rural population. You may be able to hire a local car to be on call or pay patients to cover transportation costs. At

one PIH-supported site, some patients are given transportation money so that they can keep their appointments. This money is given to them when they come for their check-up at the HIV clinic—it is for a round trip to cover their next appointment. The arrangement works well, because the patients attend the clinic when expected. While patient care always takes precedence, demand for access to vehicles for all uses will be high, so you will have to set priorities and even work out a schedule for your vehicles.

You may also want to develop some guidelines for staff use, including for nonclinical activities. In addition, think about hiring local drivers, which can provide much-needed employment for local residents and provide you with people who are knowledgeable about the local terrain. You will need to ensure that the drivers are properly licensed, as well as mindful of the country's driving laws. Taking a test drive with candidates for the job is a good way to assess their skills. Consider also other qualifications including the candidates' spoken language skills, resourcefulness, and reliability.

6. WATER SUPPLY

Obtaining an adequate supply of safe water is often a challenge at sites in resource-poor countries, where water supplies may be intermittent, contaminated, not easily accessible, or simply unavailable.

6.1 *Assessing the water supply*

Find out if there are other water projects being carried out or planned in the area, as you may be able to share costs and avoid duplicating work. A technical expert can help with the assessment, but it is also important to consult with people in the community who may know about local water sources. Some questions to answer in the assessment include:

- Is water available year-round?
- Where does the water come from? Groundwater sources (wells, springs)? Surface water sources (rivers, lakes, and dams)?
- Is the facility connected to a municipal or private water supply? If yes, how much does the water cost per month?
- Is the water distributed through piping? If yes, are the pipes in good working condition?
- Do the site's buildings use water collection methods?
- What size population (health facility staff plus local community) will the health facility's water supply cover?
- What is the average water consumption at the health facility?

Figure 14: Local workers lay pipes to bring water to the community and to Zanmi Lasante in Haiti

- How are water supplies used (sanitary facilities, laboratory, kitchen, wards)?
- Which buildings have running water?
- Is there a communal tap?
- Is maintenance needed in particular areas?
- What back-up supplies exist (storage tanks, rainwater collections)?
- What is the quality of the water? How is it tested and purified for drinking?

6.2. *Alternative strategies*

The results of the water supply assessment, your budget, and the possible future growth of the site will all affect your plan to provide or increase the water supply. It may be possible to connect or reconnect the facility to the municipal or commercial water supply system. Doing so may require that land be cleared, pipes repaired, and additional pipes laid from the water source to your facilities. The process can be costly and time-consuming if the work is not considered a priority by the municipality or company. If the site cannot be connected, you will need to develop alternative strategies for ensuring a year-round, on-site water supply with one or a combination of collection technologies, including:

- Collecting water from streams bubbling out of the ground or from mountain springs into a collection box ("spring caps"). The water can be easily contaminated if left unprotected, so a concrete structure is built around it, shielding it from parasites and debris. The water is then piped directly to taps or, if from a mountain, taken by gravity from a holding tank down the mountain to taps.
- Installing rainwater collection systems on buildings.
- Drilling boreholes for wells. Be sure to check that the boreholes have been cleaned of sediment and that the wells are covered and childproof.
- Installing a full pump system (hydraulic, electric, or solar).

PIH NOTE

The water stopped at the site in Neno, Malawi, because of a power surge in the electrical pumping system. When we had installed the system, one pump was fitted with internal sensors to pick up problems in the flow of water, while other pumps in the area had external control boxes attached to them. Power surges happen quite often, with corresponding interruptions in water flow, but with control boxes we can easily reset these pumps. Unfortunately, this power surge affected the pump with internal sensors, so we were unable to reset it. We were without water for much longer than we had expected, because the pump became nonfunctional on the day before a long holiday weekend. As soon as stores reopened, we purchased a new pump, but this time one with an external control box.

6.3 *Implementing a reliable water supply*

The following steps can help improve the reliability of your water supply:

- Determine whether the local population will be accessing water from the health facility for their community and how this will affect your usage, layout, and costs.
- Calculate all water needs, including those for sanitary facilities, laboratory, laundry, kitchen, pharmacy, and staff housing.
- Consider how the costs of ongoing maintenance will be met (by the facility, shared with the local community, by external funders).
- Determine how people will access water (buckets, communal taps, faucets in specific functional spaces) and whether it will be continually accessible from all points.
- Store collected water (in cisterns).
- Harvest rainwater by gathering it from roof gutters. When carried out properly, rainwater harvesting can serve as one of a facility's primary water supplies during rainy seasons.
- Ensure the safety of drinking water. To get a baseline understanding of a new water supply, do a broad water quality test for a number of parameters (physical and chemical pollutants, as well as pathogenic bacteria). The national government will probably have guidelines for water quality, and you can also refer to those published by the World Health Organization (WHO). If there are significant changes in groundwater from the rainfall pattern or from possible pollutants coming from agricultural activities, you may want to assess water quality more than once a year.

PIH NOTE

Constructing new water systems can sometimes have unintended effects. As part of the work on a new hospital in Lisungwi, Malawi, we expanded the hospital campus and built a new road to allow access by an ambulance. However, as a result of this construction, an existing water pump used by most of the community to obtain household water was now in a high-traffic area. To reduce risk to community members, we decided to deactivate the existing pump and provide a new one in a different but equally convenient location.

7. ELECTRICITY SUPPLY

Electricity supply, particularly in rural areas in resource-poor settings, is often intermittent or lacking, while the energy needed to provide hospitals and clinics with reliable power 24 hours a day, 7 days a week, is considerable. Electric power can be generated by different sources, and you may want to use a qualified electrician to help you determine your requirements and assess which options are most suitable to meet your needs.

7.1 *Electricity grids*

Connecting to a government or commercial grid can mean having a regular electricity supply, but if the grid has limited capacity, the site may still experience frequent outages because of the demands on other parts of the grid. However, if you are within a reasonable distance of power lines, it may be worth working with the local government or the local electric company to extend lines to the site. To determine if this is the best option for electric power at the site, find out what the installation process involves and whether meters are installed to measure electricity use. Also find out how costs for electricity are determined and estimate to the extent possible what your running costs will be. If you decide to connect to the power grid, you will need to identify the decision makers in the local government or company who can move along the installation work. Because these people might not initially view connecting your site as a priority, you may be able to develop a more responsive relationship with them by discussing how your work stands to benefit the community.

PIH NOTE

Zanmi Lasante's Cange site in Haiti gets its electricity from a hydropower station on a lake nearby, which also provides a significant portion of the electricity to the capital, Port-au-Prince. When the demand for power in Port-au-Prince increases, the electricity supply in Cange is often reduced. To avoid disruptions to our work, we would supplement the power from the grid with support from generators whenever we were carrying out surgery or some other essential activity. We would start the generator before the surgery and the entire health facility would be switched to the generator supply. This procedure became increasingly expensive, because the cost of running the generators was greater than the cost of the grid power. We found a solution with an automatic transfer switch, so that now the electricity supply is switched over automatically to the generator only if we lose power from the electrical grid. With this device, we have been able to keep our electrical supply from cutting out during critical work, and we save money at the same time.

7.2 *Generators*

Generators play an important role at sites where the government or private electricity system functions sporadically, and they also guarantee a back-up supply for critical services. However, generators and the diesel fuel to run them can be expensive, especially if fuel supplies are not available close to the site; in addition, transporting fuel and equipment to remote rural locations can be difficult.

Determining exactly what size generator to purchase depends on a number of factors. Will it be used for primary power or standby power? You will need to estimate the energy loads of equipment and lighting of all of the site's functional areas. You should also estimate the wattage required of the electrical equipment or appliances the generator will have to power—this information is typically found in the equipment manuals or on the items themselves. In addition, you will have to determine the generator's engine size and hertz (the frequency of the power output) and whether you will need automatic transfer switches (ATS). Since these decisions require technical knowledge, you should seek advice from a qualified electrician.

You will also need to consider where the generator will be housed. A structure may be necessary to support the generator at its base, and a sound canopy can be constructed to reduce noise pollution. Generators emit exhaust fumes, so an adequate exhaust system is required. While generator maintenance is ideally be done by someone on site, technical service that is locally available will still be an asset.

7.3 *Solar power systems*

A solar power system is made up of three elements: photovoltaic (solar) cells, electrochemical storage batteries, and a charge controller. Panels of these solar cells are placed on a roof or pole to convert the sun's power into electricity during peak hours. During the day the electricity from the cells charges the storage batteries, while in the evening the batteries discharge to power equipment and appliances. The charge controller keeps the batteries working within their normal charge levels, so that they are not over- or undercharged. Solar power systems have specific requirements:

- Sustained year-round sunshine at the site
- Adequate battery storage when there is no solar contribution
- Compatibility with other electric power sources at the site
- Additional construction and wiring for system controls

Figure 15: Workers install solar panels to help power a PIH-supported hospital in Rwanda

These systems can be expensive, particularly in terms of the initial capital costs. However, relying on gas-powered generators at a time of big increases in fuel prices may not be a cost-effective option for the future. Just as important, solar power systems are environmentally sound because they do not emit carbon dioxide or other greenhouse gases.

PIH NOTE

In 2009, we worked with the nonprofit organization, Solar Electric Light Fund (SELF), to install a 10,000-watt solar panel system on the roof of the Boucan Carré Hospital in Haiti's Central Plateau. After the devastating earthquake in 2010, staff working at hospitals dependent on the electricity grid in Port-au-Prince were forced to care for patients by candlelight. A three-hour drive away, the solar panels at Boucan Carré ensured that electricity was one less thing the staff had to worry about as they began treating an influx of earthquake victims.

7.4 *Implementing a reliable electricity supply*

Taking the following steps can help improve the reliability of your electricity supply:

- When assessing your electricity needs, estimate the likely electrical loads in all buildings and functional areas on the site, including equipment and lighting and the hours that electricity will be needed. Another approach is to follow the rhythm of the day and find out how and when electricity is used.
- Decide ahead of time on the type, placement, and number of electrical outlets when constructing new buildings, as rewiring is disruptive and costly once the building has been completed.
- Install a back-up supply. If the site is connected to a government or commercial electricity system, a generator or solar power should be available as a back-up source of power, and all electrical systems should be capable of functioning with each other. You can also use uninterruptible power supply (UPS) units to provide emergency power to connected equipment. UPS units are battery back-ups that supply power from a separate source when routine power is not available.
- Protect the electricity supply. Ground your equipment to prevent damage from excessive voltage and build-up of static electricity. Circuit breakers can protect circuits from overloads and short circuits. Install surge protectors on power strips, which are strips of multiple sockets with switches to turn off all connected devices when surges or spikes in electrical current occur. Install air terminals, more commonly known as "lightning rods," to divert a lightning strike from the initial point of contact through a thick cable and then to a buried copper rod called a grounding rod, thus avoiding damage to any equipment.

PIH NOTE

Doing work to provide reliable and safe electric power is sometimes necessary during the delivery of health services. When the hospital in Neno, Malawi, was being renovated, the electrician discovered that the original wiring was dangerous and had to be completely redone. To avoid disturbing patients and disrupting work, he and his team rewired the hospital ward by ward, warning staff several days in advance so that they could plan for the disruption and move patients from one room to another. Although it was hectic, frequent and direct communications between hospital staff and those managing the renovation helped the process go smoothly.

8. TELECOMMUNICATIONS

Telecommunications and Internet connectivity are key infrastructure elements for PIH. Patient information is stored and monitored in electronic medical record systems for long-term management of diseases such as HIV/AIDS. Patient referrals, emergency care, and regular communications with local and international partners all depend on reliable telecommunications, and routine program and financial management activities are carried out electronically.

TIP: *Staff members benefit from Internet connectivity by being able to access material for their professional development and to keep in touch with family and friends.*

You will probably require a variety of equipment to meet your communications needs. However, before purchasing any equipment, find out about the local telecommunications infrastructure and its reliability. Look into equipment cost and the availability of technical support. Also consider whether most of your communications will be local or long distance.

8.1 *Radios and telephones*

With the information you gathered and with the site's location and size in mind, the table below can help you determine the type of radio and telephone that will best meet your communications needs.

Equipment	Advantages	Disadvantages
1. High-frequency radio	• Good for two-way communication • Higher reception range than FM/AM radios • Low cost	• Difficult to connect to telephone network, although there are complex systems that do this
2. Landline telephone	• Low cost if infrastructure is already in place • Not dependent on power source	• Connections to grid required • Possible delays in installation
3. Cellular telephone	• Increasing coverage in resource-poor areas, although service still can be limited in rural areas • Costs are decreasing • Can communicate via Short Message Service (SMS) • Emergency data service plans available from an Internet service provider (ISP)	• Voice connections can be unreliable, depending on coverage • Frequent charging required • Power source required
4. Satellite telephone	• Good coverage for remote areas • Pay-as-you-go plans available	• Costly • Power source required and power consumption is high relative to cellular telephone • Must be used outdoors with clear view of sky

Figure 16: Comparison of different types of radios and telephones

PIH NOTE

During our first year-and-a-half at the mountain clinics in Lesotho, communicating with our team in Maseru, the capital city, was a real challenge. Cell phones couldn't function there. We bought a satellite phone for each site but they didn't work most of the time—we had to walk for an hour, climb a high mountain, and arrange the antenna in a certain way, often to no avail. The only way we could consistently communicate with Maseru was to pass along a note with the pilots from the Mission Aviation Fellowship. The situation changed dramatically when we installed solar panels and Internet connectivity.

8.2 *Computers, software, and peripherals*

Computers support a variety of functions important for clinical work, including an electronic stock management system (ESMS) for the pharmacy, recording test results in the laboratory, and recording patient data in an electronic medical record (EMR) system. They are also invaluable for managing your finances and keeping track of administrative tasks and program operations. Computers are ideally suited to keeping a record of how programs have developed and providing easy access to important contracts, reports, and other relevant information.

Figure 17: Staff enter patient data into OpenMRS, an open-source electronic medical record system, at Zanmi Lasante in Haiti

Desktop computers are intended for regular use at a single location, in contrast to laptop or portable computers. Desktops, typically requiring 350W of power, are easier to secure, and spare parts and extensions are more likely to be standardized, resulting in lower prices and greater availability. Laptops, on the other hand, have lower power consumption (typically 60-90W), provide battery back-up, and can be more convenient in limited spaces. There are desktop alternatives such as "thin client" computers that consume even less power (15-25W) than the average laptop. These devices are essentially computer terminals that depend heavily on some other computer, the server, to perform functions. They do not have their own operating system or do their own data processing. These are cheaper than other computers, have a low risk of theft, and are easy to replace. However, they rely on a network connection to a server, which can cause problems in an environment with unreliable infrastructure. Most of these models do not have a battery for back-up during power outages.

You may be able to purchase computer equipment locally. Although the items may be more expensive than those outside the country, you may be able to offset the increased price by saving on shipping costs. The number of computers will depend on usage at your site, your budget, and the existing telecommunications infrastructure. (For more information on the factors influencing such purchasing decisions, see *Unit 4: Managing a procurement system*.)

PIH NOTE

We developed an open-source, web-based EMR system that has made a positive impact on all aspects of our work. We use it for planning, forecasting, and patient tracking, as well as for reporting, monitoring, and evaluating our health services. When we install the system at our sites, we use these general guidelines to determine the quantity and location of computers:

- *Data entry: one computer per data-entry staff member*
- *Clinical usage: one to three computers, depending on the number of doctors and their degree of interaction with the system*
- *Drug warehouse: one computer for the warehouse manager in any site large enough to have a warehouse separate from the pharmacy*
- *Laboratory: one computer for each laboratory technician*

In addition to software for basic office functions such as word processing, spreadsheets, virus protection software, and email, you may want to add software for presentations, images, statistical analysis, and an EMR. If it is not already preloaded on the computer, you will also need a browser for the Internet. Consider, too, software that allows users to make free telephone calls and chat over the Internet, with small fees for calls to landlines and cell phones.

Also consider your requirements and budget for peripherals to support your telecommunications needs, including printers, scanners, a projector and screen, and a digital camera.

8.3 *Implementing a reliable telecommunications system*

Computer viruses, limited technical support, and users who are unfamiliar with best practices for computer use can limit the benefits of these technologies. The following guidelines can help meet these challenges:

- Whenever possible, provide staff with training on basic computer use, word processing, spreadsheets, email, and any specialized systems. Developing guidelines for electronic communications, including security and privacy issues, also helps to ensure good management of these resources.
- Back up data to avoid loss of critical information. You can back up information from your computer to a CD-ROM, to an external hard drive that you plug into your own computer, or to a small, portable memory stick called a flash drive. Backing up data can also be done on a reliable server housed off site.
- If you have a robust power supply and have created a local area network or are using an external Internet provider, or both, consider investing in network management. For a medium-sized network of 10 to 20 computers, typical network management services run on a single machine or three separate ones and include the following:
  - A network management server to measure and analyze traffic on the network, helping to ensure that bandwidth is available for the most important uses

– A proxy server to cache frequently viewed web pages and host important antivirus and operating system updates, which reduces your overall bandwidth use
– A firewall to block unwanted network traffic and protect the network from computer viruses and malicious attacks

TIP: *Be mindful of ongoing operation and maintenance costs as you plan how your network will be managed and maintained. Arrange for good local technical support or designate a qualified staff member to provide troubleshooting.*

8.4 *Internet connectivity*

In your planning, think about how much of your bandwidth requirement is local—that is, communications that occur between sites or between buildings at one site—and how much is global, provided by an Internet service provider outside the local area network and typically outside of the country.

If most of the traffic on your network can be classified as global, it is worth investing in a robust Internet connection. If a substantial amount of your traffic can be classified as local, it may be worth purchasing a single Internet connection and investing in hardware to create fast wired or wireless links within the site or between sites.

TIP: *Local links allow fast access to servers for file storage, electronic medical records, and voice over Internet protocol (VoIP) connections. Although there are no subscription costs, operational and maintenance costs increase as more hardware is installed.*

8.4.1 VSAT systems[2]

In rural health facilities where landline or cellular communication can be unreliable, very small aperture terminal (VSAT) systems—a satellite dish and the electronic equipment to transmit and receive information via a communications satellite in space—have become the preferred option. For example, VSATs provide Internet connectivity at our most remote mountain sites in Lesotho.

Figure 18: PIH-supported mountain clinics in Lesotho are connected to the Internet by satellite (VSATs)

Check first on license requirements in-country. Some countries have heavily

[2] Twinomugisha, A. & Aluoch, S. (2005). *The VSAT buyers guide: A guide to selecting, procuring and implementing VSAT technologies for developing countries.* Ottawa, Canada: International Development Research Center (IDRC). Retrieved online at: *http://www.gesci.org/old/files/docman/The_VSAT_Buyers_Guide.pdf.*

regulated telecommunications sectors, and VSATs may be restricted or may have very expensive licensing costs. Obtaining a license can also be a long process, so it is important to find out about the requirements at the outset. It may be easier to negotiate the license through VSAT service providers or vendors of VSAT equipment.

Because planning a VSAT system is time-consuming and involves technical, managerial, and financial issues, try to ensure that one person is responsible for the overall effort. In cases where there is no IT specialist on your team, you may want to use external expertise to help you determine your requirements and the technical specifications. In assessing your needs, think about your functional and technical requirements:

- What uses do you require? Email, Internet browsing, videoconferencing, Voice over Internet Protocol (VoIP)?
- What access do you need? What times of day will you most need it, or should it be operational 24 hours a day? What is the minimum acceptable time between failures and what should be the maximum recovery time in case of failure? Should the system have different levels of access depending on the type of user?
- What capacity do you need? How many sites should be serviced? How many users will there be at each site? How much bandwidth does one person need and how much should be shared? What might be your bandwidth requirements in the future?
- What power source and power back-up is available? What is the load of all the equipment and devices you want to connect to your VSAT?
- Do you plan to share access with local government, other partners, and/or the community? Sharing Internet access with government partners especially can be a powerful and practical demonstration of solidarity and good will, and can help to build public sector capacity.

Technical specifications will cover the location of the teleport or hub that manages the VSAT network's connections with the satellite—the teleport/hub is often located with the service provider if you are purchasing a small number of VSATs. You will also have to determine what kind of VSAT equipment is needed on site, including the size of the dish.

TIP: *In order to properly receive the feed from the satellite, VSAT installations in areas far to the north or south of the equator may require much larger dishes than at other locations. They may also need concrete support structures because of their large size.*

It is helpful to develop a budget, differentiating between one-time and recurrent costs, before finalizing your tender for bids. One-time costs include the purchase of equipment, the license to operate the VSAT, shipping if the equipment will be purchased outside of the country, and any spare parts you can include in your initial purchase. Recurrent costs include all the telecommunications services provided by the outside company, such as the teleport/hub services, connection to the Internet, and bandwidth usage of your network.

Also factor in the costs of your power supply and maintenance support. Check for any in-country suppliers, because access to one can mean better ongoing maintenance support later on; you will also be supporting a local business. Also investigate the possibility of splitting the services you require between different suppliers instead of relying on one company to fulfill them all.

Before the VSAT system is installed, you may need a site survey to determine the location of equipment, because the VSAT must have a clear, unobstructed view of the sky in the direction of the satellite. Wherever possible, try to install lightning protection equipment. The installation process can be costly, because the equipment will have to be unpacked, assembled, and connected; the dish pointed; and equipment powered and configured. These processes are usually carried out by the service or equipment supplier and require skilled, trained, and experienced personnel. To the extent possible, try to use local workers for any construction work that may be needed.

Once the system is installed, the supplier must test the system to ensure that it is functioning properly under normal conditions. Procedures include:

- Powering the VSAT to ensure that all equipment starts up
- Testing for the ability to receive and transmit to the satellite

Whenever possible, the supplier should provide training on site as well as relevant documentation. You will need to arrange for ongoing maintenance and support.

8.4.2 Long-range wireless Internet access

Worldwide Interoperability for Microwave Access (Wi-Max) and fourth-generation (4G) cellular networks are becoming viable options in many urban centers of developing countries. With wireless systems, you do not need to run cables or dig trenches to install the systems. These networks can provide coverage over long distances by using enough access points to create overlapping cells of coverage, or "hot spots." Using laptop computers fitted with particular access cards, a mobile access environment is created where people can connect anywhere within the hot spots. The table below compares these networks with VSAT systems.

Wi-Max and 4G cellular networks	VSAT systems
Different levels of bandwidth available	Different levels of bandwidth available
Hardware costs lower than with VSAT systems	Hardware costs include satellite dish and electronic equipment
Licensing requirements covered by local service provider	Licensing requirements not covered by provider and required by government
Connectivity not always reliable from local provider	Connectivity more reliable from international service provider
Coverage limited to urban areas	Coverage in urban and rural areas

Figure 19: Comparison of Wi-Max and 4G cellular networks to VSAT systems

CONCLUSION

In your work to bring the benefits of high-quality health facilities and modern technologies to resource-poor settings, your organization will likely have to build at least some of the infrastructure from scratch. Although the challenges of doing so can seem great, by planning carefully and engaging skilled, committed partners, your organization can, over time, implement significant improvements to a site's water supply, power supply, sanitation system, and telecommunications capabilities. Important also is your collaboration with the MOH and local authorities who can ensure that you execute infrastructure projects in accordance with country standards, and at the same time help your organization earn the trust of the government and the people in the community. Planning and outfitting the health facility itself entails further challenges, which, successfully met, will result in a clean and well-maintained site that sends a powerful message that your organization upholds the dignity of patients, their families, and your staff.

Resources

WORKS CITED

Rich, M. (ed.). (2003). *The PIH guide to the medical management of multidrug-resistant tuberculosis.* Boston, MA: Partners In Health.
http://www.pih.org/publications/entry/pih-guide-to-the-medical-management-of-multidrug-resistant-tuberculosis

Twinomugisha, A. & Aluoch, S. (2005). *The VSAT buyers guide: A guide to selecting, procuring and implementing VSAT technologies for developing countries.* Ottawa, Canada: International Development Research Center (IDRC).
http://www.gesci.org/old/files/docman/The_VSAT_Buyers_Guide.pdf

SELECTED RESOURCES

Site Assessment and Construction

Journal of Construction in Developing Countries
http://www.usm.my/jcdc/
The journal offers open access to peer-reviewed publications about the built environment in developing countries. Topics covered include planning, urban economics, rural and regional development, housing, management and resource issues, sustainability, knowledge and technology transfer, construction procurement, facilities management, information and communication technologies, strategies and policy issues, design issues, and conservation and environmental issues.

Management Sciences for Health. (2006). **Making your clinic building work.**
http://erc.msh.org/mainpage.cfm?file=2.1.3.htm&module=quality&language=English
This resource provides managers with some basic guidelines for evaluating clinic space requirements and for organizing their clinic to improve how the space is used to meet both patient and staff needs.

Partners In Health. **Health Facility Survey.**
http://model.pih.org/health_facility_survey
This survey was developed to understand the needs and capacities of health care facilities to guide site-strengthening activities. The tool was piloted and revised based on initial experience and then administered to a number of health care facilities in Rwanda.

Infection Control

Bock, N.N., Jensen, P.A., Miller, B., & Nardell, E. (2007). **Tuberculosis infection control in resource-limited settings in the era of expanding HIV care and treatment.** *Journal of Infectious Diseases, 196*(Suppl.1): S108–13.
This article illustrates how infection control measures can reduce the risk of TB transmission in resource-limited settings on the basis of a three-level hierarchy of controls, including administrative or work practice, environmental controls, and respiratory protection.

Escombe, A.R., Oeser, C., Gilman, R.H., Navincopa, M., Ticona, E., Pan, W., Martínez, C., Chacaltana, J., Rodríguez, R., Moore, D., Friedland, J.S., & Evans, C.A. (2007). **Natural ventilation for the prevention of airborne contagion.** *PLoS Medicine, 4*(2): e68.
http://www.plosmedicine.org/article/info:doi/10.1371/journal.pmed.0040068
This article discusses the measured benefits of natural ventilation for infection control in resource-limited settings.

Francis J. Curry National Tuberculosis Center. (2007). **Tuberculosis infection control: A practical manual for preventing TB.**
http://www.nationaltbcenter.ucsf.edu/TB_IC/
This manual provides consistent and up-to-date information about the guidelines and regulations pertaining to TB infection control, methods of reducing the risk of TB infections, and facility-specific guidelines for reducing the risk and dealing with potential exposure.

Rich, M.(ed.). **The PIH guide to the medical management of multi drug-resistant tuberculosis.** Boston, MA: Partners In Health.
http://www.pih.org/publications/entry/pih-guide-to-the-medical-management-of-multidrug-resistant-tuberculosis
This guide is intended to be a resource for physicians and other health care professionals who provide care and treatment to patients with multidrug-resistant tuberculosis in DOTS-Plus projects in resource-poor areas.

Water and Sanitation Facilities

IRC International Water and Sanitation Centre
http://www.irc.nl/
This site offers access to publications, including Thematic Overview Papers that combine recent experiences, expert opinions, and foreseeable trends with links to informative publications, websites, and research information; a digital library; information about more than 650 organizations and networks in the water supply and sanitation sector related to developing countries; and advisory and training services.

Kahn, L., Allen, B., & Jones, J. (2000). **The septic systems owners' manual.** Bolinas, CA: Shelter Publications.
This manual is an illustrated introduction to how a basic septic system works and what to do if things go wrong. It includes information about soil and the ability of microorganisms to purify water-borne pathogens.

Mihelcic, J.R., Fry, L.M., Myre, E.A., Phillips, L.D., & Barkdoll, B.D. (2009). **Field guide to environmental engineering for development workers: Water, sanitation, and indoor air.** Reston, VA: American Society of Civil Engineers Press.

This is a fully illustrated handbook for international engineering service projects that involve water supply and treatment, watersheds, sanitation systems, and indoor air quality. Specific technical guidance is offered for the design and construction of multiple systems for water supply, water and wastewater treatment, and flood storage and drainage.

Stanford, M. (ed.). (2007). **Lessons from a low-cost ecological approach to sanitation in Malawi: Field note.** Nairobi: Water and Sanitation Program Africa. World Bank.
http://www.wsp.org/wsp/
This working paper discusses the efforts of the Ecological Sanitation Program (EcoSan) in Malawi to popularize ecological sanitation

WaterAID
http://www.wateraid.org/
WaterAID's Toilet Technology Flipbook is of particular interest to those looking for latrine technologies. Access is also provided to the Low Cost Toilet Options Handbook of the United Kingdom's Department for International Development and the Water, Engineering and Development Center of Loughborough University.

World Health Organization. **Water, Sanitation and Hygiene: Fact Sheets on Environmental Sanitation.**
http://www.who.int/water_sanitation_health/emergencies/envsanfactsheets/en/index.html
This resource includes access to information in four major themes: planning, water supply, sanitation, and hygiene education.

Medical Waste Disposal Facilities

World Health Organization. **Healthcare waste and its safe management.**
http://www.healthcarewaste.org/en/115_overview.html
This website provides access to information on four themes: management, training, regulation, and technical aspects; and focuses on each from the national level down to primary healthcare centers. There is also a set of five searchable databases that provide resources in the form of documents, website links, country information, case studies, and technical options.

Prüss, A., Giroult, E., & Rushbrook, P. (eds.). (1999). **Safe management of wastes from healthcare activities.**
http://www.who.int/water_sanitation_health/medicalwaste/wastemanag/en/
This World Health Organization handbook pays particular attention to basic processes and technologies that are safe and affordable, sustainable, and culturally appropriate. There is a separate chapter for resource-poor settings that summarizes all the simplest and least costly techniques that can be employed for the safe management of healthcare wastes.

Transportation

Riders for Health
http://www.riders.org
This nonprofit works in seven African countries to manage and maintain vehicles used in the delivery of health care and other vital services to rural communities.

Electricity Supply

National Lightning Safety Institute
http://www.lightningsafety.com/
This website includes tools for personal and structural lightning safety.

Solar Electric Light Fund
http://www.self.org/
This nonprofit organization's site offers consultancy services (including project design and management, training and capacity building, technology assessment) and carbon offset services for businesses, NGOs, and special events. It also offers links to external resources regarding solar power and wireless communications in developing countries.

Telecommunications

Twinomugisha, A. & Aluoch, S. (2005). **The VSAT buyers guide: A guide to selecting, procuring and implementing VSAT technologies for developing countries.** Ottawa, Canada: International Development Research Center (IDRC).
http://www.gesci.org/old/files/docman/The_VSAT_Buyers_Guide.pdf
This guide is intended to aid in the purchase of VSAT systems services. It provides information on processes associated with selecting, acquiring, and maintaining VSAT systems.

Flickenger, R., Belcher, M., Canessa, E., & Zannaro, M. (2006). **How to accelerate your Internet.**
http://bwmo.net/download.html
This guide provides practical information on getting the most out of an Internet connection with limited bandwidth. It provides an overview of networking basics, and outlines techniques for monitoring the network traffic, managing different types of traffic, and optimizing the network for specific usages.

Flickenger, R. et al. (2007). **Wireless networking in the developing world.** 2nd ed.
http://wndw.net/
The emphasis in this guide is on building infrastructure links intended to be used as the backbone for wide-area wireless networks. With that goal in mind, information is presented from many points of view, including technical, social, and financial factors.

Global Health Delivery Project (GHDonline). (2008). **Health IT: Community home.**
http://www.ghdonline.org/tech/
This online forum provides professional discussions about choosing IT equipment for the field, including thread topics, such as: data capture, the right device for the job, an ideal computer for a rural health facility, and wireless networking where electricity is scarce.

Global PHAT. (2010). **Effective electronic medical records: Moving beyond the technology.**
http://www.ghdonline.org/uploads/G-PHAT_Panel_II_-_All_Materials.pdf
This video and notes from a panel session at the Harvard School of Public Health in May 2010 discusses and compares installation and implementation strategies for different types of electronic medical record (EMR) systems.