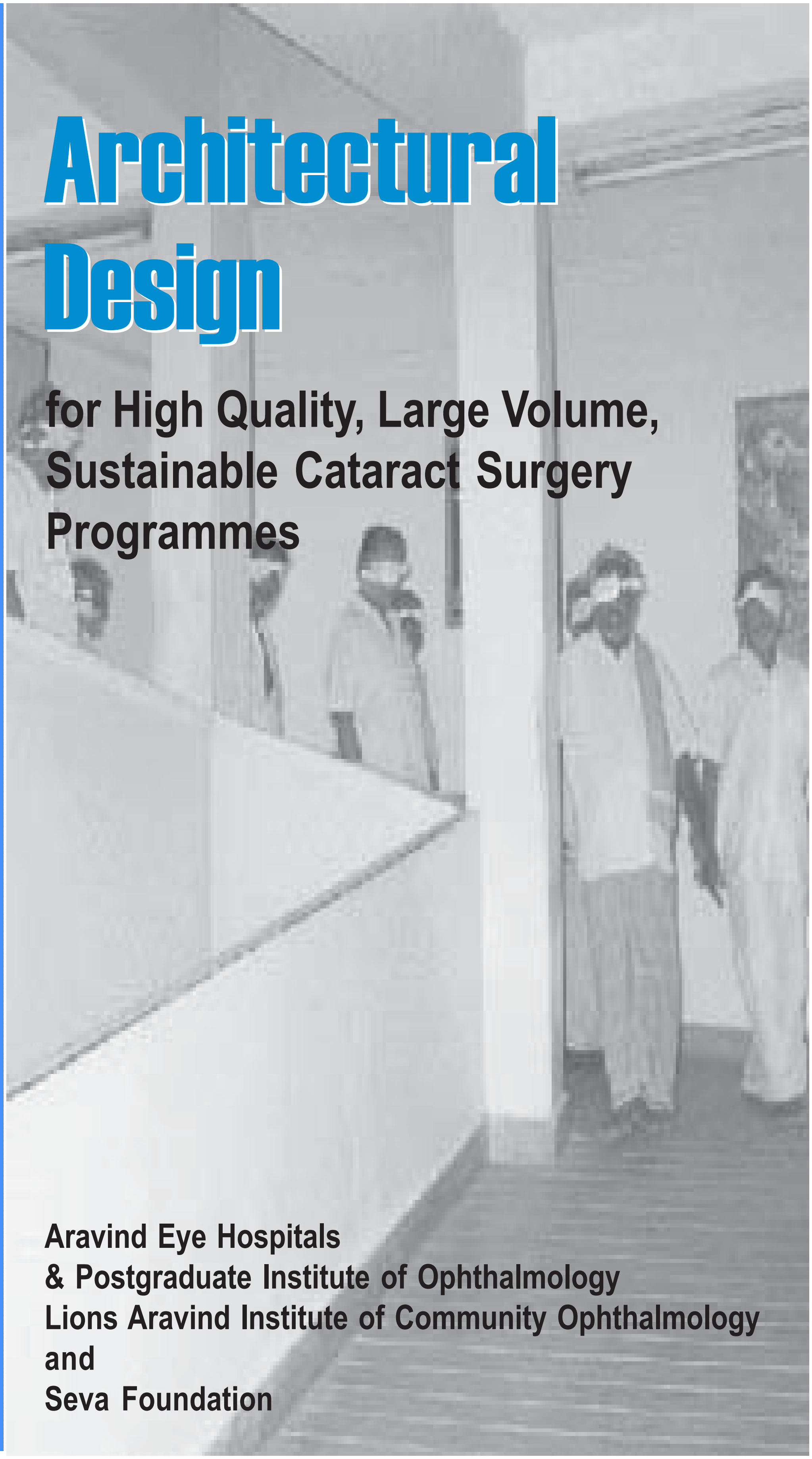

QCS SERIES

Architectural Design

for High Quality, Large Volume, Sustainable Cataract Surgery Programmes

Aravind Eye Hospitals
& Postgraduate Institute of Ophthalmology
Lions Aravind Institute of Community Ophthalmology
and
Seva Foundation

QCS SERIES

Architectural Design

for High Quality, Large Volume, Sustainable Cataract Surgery Programmes

The Quality Cataract Surgery Series is a set of modules explaining principles and techniques for developing high quality, large volume, sustainable cataract surgery programmes, especially in settings where cataract causes much needless blindness. Each module is based on the practices of Aravind Eye Hospitals in South India, with input from other successful programmes.

The set includes the following modules:

- Introduction
- Clinical Strategies
- Paramedical Contributions
- Management Principles and Practices
- Community Outreach Initiatives
- Financial Sustainability
- Architectural Design

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This series of modules can be improved with your help. If you have ideas or suggestions for ways the QCS series could better meet your needs, please write to the QCS Series Editor c/o Aravind Eye Hospitals. We welcome your comments and experiences. Thank you for your help.

Quality Cataract Surgery Series
Aravind Communications / LAICO
72, Kuruvikaran Salai, Gandhinagar,
Madurai 625 020,
Tamil Nadu, India

Phone : 452-537580
Fax : 452-530984
Email : communications@aravind.org

Contents

About the Author

Christie Johnson Coffin, M. Arch., NCARB, practises architecture with The Design Partnership in San Francisco, California, U.S.A. She emphasises making graceful, friendly places for people and designing sustainably with future generations in mind. She enjoys finding the right physical form to fit a social need, but stresses that some flexibility may be important in order to accommodate change over time.

Christie consulted during the design phase of the Lumbini Eye Hospital in Nepal for Seva Foundation, encouraging attention to patient, family and staff needs, principles of efficient patient flow, design with climate, and anticipating future needs. She has worked on ophthalmic facilities for Kaiser Health Plan and the US. Air Force. Other completed health care projects include: California Medical Center in Los Angeles, University of California Irvine Neuro-Psychiatric Institute, Kaiser Mosswood Building, North Richmond Center for Health, and recently, the programme and conceptual plan for National Taiwan Children's Hospital, Taipei.

Other completed buildings include major university research facilities at the Universities of Oregon and California, as well as schools, offices and housing. She has taught architecture at the University of Oregon, the Massachusetts Institute of Technology, the University of California Berkeley and California Polytechnic State University, San Luis Obispo. She is co-author with Roslyn Lindheim and Helen Glaser of *Changing Hospital Environments for Children.*

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- Christie Johnson Coffin

Introduction

We have the obligation to understand our past, to respect and preserve it, and to learn to recognise the appropriateness of architectural innovations we introduce into it.

- The Aga Khan, Beijing, October 1981

Rationale

Creative health care professionals can function well in poor surroundings. But if your goal is a high quality, large volume, sustainable cataract surgery programme, your health care professionals should not be forced to overcome unnecessary obstacles. Architectural layout and building qualities can support (as well as limit) productivity, quality of care, and cost effectiveness.

Objectives of the architectural design module

- To record lessons learned in the design, construction (or renovation), and use of successful eye care facilities.
- To show ways that architectural layout and features can more effectively support high quality, large volume, sustainable cataract surgery programmes.
- To describe ideal characteristics to consider in adapting a present facility, buying an existing building with the option of renovating, or starting construction of a new building from the beginning.
- To remind those responsible for architectural decisions to ask the right questions to the right people at the right time in the planning process.

Examples and models

Design considerations suggested in this module are drawn from a variety of sources. The most commonly used sources include:

- Aravind Eye Hospitals at Madurai, Theni, Tirunelveli and Coimbatore, in Tamil Nadu, India
- Lumbini Eye Hospital, Nepal
- L.V. Prasad Eye Institute, Hyderabad, India
- Kaiser Foundation Hospitals, primarily California, U.S.A. locations

These facilities have differing professional practices, differing community contexts, and differing usage of space. Not every idea will be appropriate to replicate in your context. However, lessons learned in the design, construction or renovation, and use of the above health care facilities will show design features and considerations that promote high quality, large volume, sustainable cataract care.

Aravind Eye Hospital, Madurai, India

Lumbini Eye Hospital, Nepal

L. V. Prasad Eye Institute, Hyderabad, India

Design Principles

This module is divided into seven design principles:

1. Hygiene
2. Appropriate and sustainable technology
3. Function
4. Response to social context / community design
5. Beauty
6. Economic issues
7. Facilities development process

The goal of this module, then, is not to predetermine a design for your eye care facility, but to outline its most significant qualities and requirements, and to provide conceptual diagrams. Remember that your design will differ significantly based on local conditions, resources readily available, the cultural context, and the site.

Old buildings, like old forests, are appraised as intergenerational equity.

- Stewart Brand

Renovation versus new construction

Please note that architectural design principles and considerations are not just for the construction of a new building. If an appropriate facility already exists, it is often not necessary to construct a new building. Since the differences between new construction and renovation of older buildings are few, this module will be helpful for several different architectural projects:

- Building a new facility on a new site
- Adding another building to the current site
- Acquiring an existing building and renovating it
- Renting an existing building and negotiating with the landlord to make changes to it (sometimes called leasehold or tenant improvements)
- Redesigning and renovating the current building.

Design considerations specifically for renovation are ***highlighted* throughout this module (marked with***), especially in section 7, The facilities development process.**

Space categories

This module will concentrate on the overall qualities desired in a new or renovated eye care facility, with a special focus on:

- Surgical spaces for cataract and other eye surgery
- Diagnostic and treatment spaces for outpatient care
- Patient bedroom spaces for inpatient care

At the end of the module are room data sheets for these three spaces, and one blank template. Room data sheets help to organise key information on requirements for each space.

Don't forget that you will also want to decide on important design features for other spaces in your eye care facility, such as entrance and reception areas, administrative offices, conference halls or classrooms, library, medical records system, meditation rooms/lounges, canteens or dining halls, etc.

Prioritising design principles

The order in which you consider the seven design principles might change when you consider different spaces within your eye care facility. While hygiene must always be the priority in a health care facility, beauty as well as response to social context and community design, for example, will probably be more important considerations in patient bedroom spaces than in surgical spaces. Your prioritisation of the design principles depends on your situation.

A note about terminology:
What we are calling 'surgical spaces' are called many things in different countries: operating rooms, operating theatres, surgical theatres, surgical suites.
'Diagnostic and treatment spaces' are sometimes called outpatient departments, ambulatory care divisions, primary health clinics.
'Patient bedroom spaces' are sometimes called wards, patient accommodation, patient rooms, beds, inpatient division.
We are using the term "spaces" to avoid confusion, but some of these other terms will be seen in quotes and examples found in this module.

1. Hygiene

The all-time best models of superb maintenance, in terms of both design and administration, are hospitals and naval ships. For them, maintenance issues are "life-critical", and it shows. Inspection is routine and exhaustive. Maintenance tasks are divided into "preventive" and "corrective." In-house maintenance staff are on call 24 hours a day, and all working equipment is kept in good-as-new condition.

- Stewart Brand

Hygiene, the science of establishing and maintaining conditions or practices (such as cleanliness) conducive to health, is named after Hygieia, the goddess of health in Greek mythology. With our modern understanding of the causes of infection, we believe hygiene (in its narrower definition of cleanliness) should be the first design principle considered in a hospital design or renovation.

Although a lot of the responsibility for hygienic practices rests on hospital staff (practical infection control is discussed in the Clinical Module), the following architectural design features can make hygienic conditions in your hospital much easier to ensure.

a. Limit dust and mould

- Are we going to have a dust problem?
- When? During which season(s)?
- At what time of day?
- What is the direction of prevailing winds?
- How is the dust going to get in?
- Are we going to have a mould problem?
- Where will it come from?
- How will our design prevent and mitigate these problems?

Dust makes it difficult to provide excellent eye care. Dust can irritate an already sensitive eye. Dust can carry infection. Yet in communities with long dry seasons, dust is everywhere. It may be increased by the presence of unpaved roads. Water may be expensive, limiting both road sprinkling and gardening. The potential for contamination of dust with animal and vegetable wastes increases the need to control dust in the medical environment.

Mould contamination has been identified as a major contributor to building-related illness and poor indoor air quality. [. . .] Some moulds are known to be allergenic, pathogenic or toxigenic.

- Jim Holland, Restoration Consultant

Mould can be even more critical and difficult to deal with than dust, especially in humid environments. Mould spores are everywhere. As mould growth becomes extensive, it can cause adverse reactions and infections. Mould can also cause structural damage to buildings. If you see or smell mould growth, look for the water or moisture source and try to stop or prevent it. The necessary moisture for mould growth can simply come from prolonged high humidity, or from more catastrophic events such as floods, sewer backflows, leaky roofs or plumbing leaks. By preventing an accumulation of moisture or water, you prevent mould growth. But sometimes the source is hidden.

These problems do not always have easy solutions. One ward we visited at a neighbouring hospital is located beside a well-used road. To cut down on dust and resulting potential for infection, windows are closed, even on very hot days. The lack of fresh air is stifling and significantly detracts from human comfort in the ward.

High quality air conditioning can be used to manage dust and reduce particulates to an acceptable level, but both 'first costs' (the costs of purchasing an air conditioning system) and operating costs are very high. Power outages may limit effectiveness. Lack of access to trained air conditioning repair crews and suitable replacement parts may further limit reliability. And, of course, air conditioning systems might contribute viruses, bacteria, moulds and other contaminants to the air.

Even in situations where full air conditioning is practical, a logical first step can be to minimise dust and dirt, thus contributing to air conditioning efficiency and improving air quality during system failures. Only with measures such as the following in place can one expect the filters on the air conditioning system to function efficiently.

At Aravind Eye Hospital in Madurai, India:

- **Most sensitive activities are located above the ground floor. Surgery is up one level. Upper levels tend to be less dusty. Activities closest to the main entries and to adjacent streets will tend to receive the most dust.**
- **Most sensitive activities are located in the inner part of the facility, where better control of dust can be achieved. Surgery is not located on the street side of the hospital.**
- **The medical facility is entered through a heavily planted garden. Leaves are periodically hosed off as they gather dust. Unfortunately, water limitations do not make this practical throughout the facility.**
- **Sprinkler trucks patrol the hospital neighbourhood to lay the dust.**
- **Some nearby streets have been oiled or paved.**
- **Street cleaning is on-going.**
- **Mopping and cleaning within the hospital facility occurs three times daily.**

Preventing infection is more cost effective than curing it. And infection can turn curable blindness into incurable blindness.

- M.B. Raveendran, L.V. Prasad Eye Institute

b. Hand washing everywhere

- Who must wash their hands? Why? When? How often? Where?
- What might be their reasons for not washing their hands?
- Do they understand why it is important?
- How will we design the facility so it is convenient for them to wash their hands often?
- What cultural and environmental issues must we consider?

Without question one of the best ways to limit infection is to make hand washing natural and easy at all times within the hospital. Hand washing sinks can be shared between work stations to avoid expense, but should always be in view. Repeated studies indicate that the slightest inconvenience (requiring extra steps or time) will result in even trained medical personnel taking shortcuts. Consideration of local practices and customs with respect to cleanliness should be incorporated into the planning and design of hand washing sinks.

- **At Aravind Eye Hospital, because plumbing is expensive, hand washing is often shared amongst several work stations, so that it is not necessary to put a wash basin in every room.**
- **In one American clinic, a decorative hand washing sink is the centrepiece of a cluster of diagnostic and treatment rooms.**
- **In the C.K. Choi Building, at the University of British Columbia, Vancouver, Canada, sink faucets are spring loaded to shut off automatically, reducing the amount of water wasted in handwashing.**

Scrub areas are, of course, an essential part of surgical spaces and are best located immediately outside each operation theatre or surgical suite. Due to the fine aerosol mist that is given off in the scrubbing process, these areas should be separated from any clean areas, such as surgical spaces, clean sterile work rooms, or substerile rooms.

Infection control practices are stringent at LVPEI because we have determined that it costs us 4-6 times more to keep infected patients in our hospital than to be extremely careful in all our infection control practices.

- M.B. Raveendran

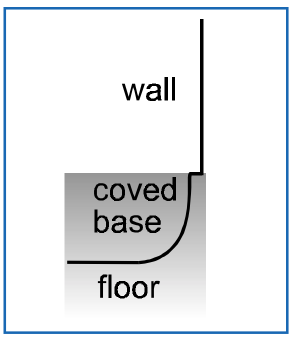
c. Asepsis

- What is our current infection rate?
- What methods do we use now to control infection?
- Where are the infections coming from?
- Does the design of our current surgical spaces contribute to sepsis? How?
- How will the design of our new surgical spaces contribute to asepsis?
- How can we design for maximum capacity without compromising our infection control?

Asepsis is the condition of being free from pathogenic microorganisms, and the methods for preventing infection. Sepsis is a toxic condition resulting from the spread of bacteria or their products, from a focus or starting point of infection.

Studies have shown that most infection originates intraoperatively (during) or immediately after surgery. ENSURE THAT YOUR SURGICAL SPACES ARE YOUR TOP PRIORITY. A surgical space is shut down as soon as an infection trend is noticed. For this reason alone, it is important to have more than one surgical space.

- **Aravind Eye Hospital in Madurai, has nine major operating theatres, each with three operating tables, plus one minor operating theatre specifically for septic care.**
- **At L.V. Prasad Eye Institute, a sterile corridor for delivery of sterile supplies surrounds their surgical spaces and acts as second barrier to infection. They believe this design feature has significantly contributed to a low infection rate.**



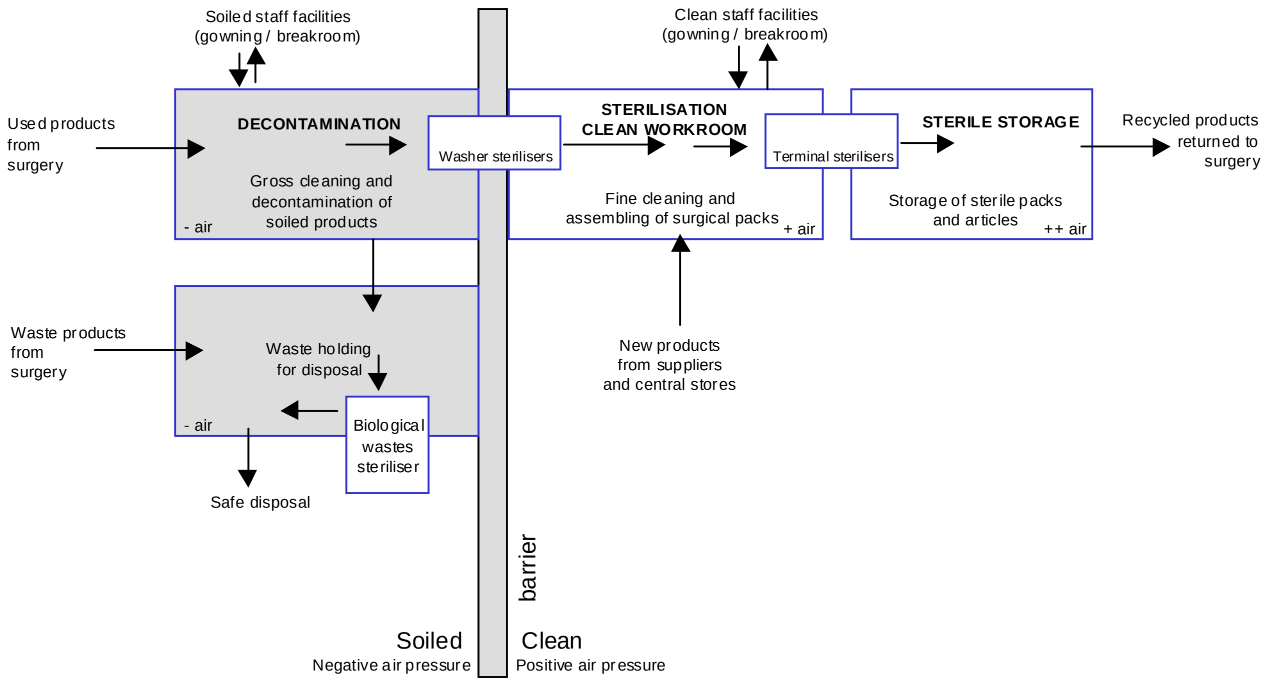
Try to use a coved base for flooring to eliminate cracks between floors and walls, particularly in the cleanest areas such as surgical spaces and sterile storage, and in the hardest to clean, and often dirtiest, areas such as toilets and trash/garbage rooms.

d) Central sterile supply

- How can we design our central sterile supply to be effective as well as efficient?
- How can we ensure consistent accessibility to sterilised materials without compromising surgical efficiency?

An area of particular interest in architectural planning and design is providing spaces to clean and sterilise medical supplies and instruments, especially recycled materials. With ever increasing levels of HIV infection, this already important goal cannot be over-emphasised. The protocols for handling soiled materials, washing and decontaminating them, and packaging them for terminal sterilisation and reuse are critical and have been well established. No facility can afford to use all disposable instruments, yet using contaminated instruments can cause serious secondary disease in staff and patients.

Central Sterile Supply



The most careful central sterile departments are arranged in three parts:

i. Decontamination

In decontamination, soiled instruments and devices are cleaned and made ready for sterilisation. This space is separated from any clean areas. In many hospitals, decontamination staff have their own wash up and dining facilities and do not mingle with clean staff on the days that they are assigned to this duty.

Ventilation is important. It is typical to separately ventilate this area and arrange for a negative air pressure so that air does not rush into other spaces when the doors are open. A simple means to accomplish this is through the use of a powerful exhaust fan.

ii. Sterilisation/Clean workroom

Often instruments are passed from the decontamination room to a clean room through a pass-through washer-steriliser. This insures that only after initial sterilisation will an instrument enter the clean portion of central sterilisation, and also insures that the fine aerosol of water that may spray from an instrument during cleaning cannot contaminate the clean instruments. In the clean room, instruments and objects are wrapped for terminal sterilisation and then taken to a sterile storage area to await use.

Again, ventilation is important. A steady supply of clean, dust-free air is desired. The room should be at a positive pressure so that soiled air from surrounding spaces does not come in when the door is open. It is considered good practice to introduce clean air high in the space and remove exhaust air near the floor.

Staff typically work only in the clean area or only in the decontamination area on a given day. Staff first scrub and then put on clean gowns, booties, hats, gloves, and often masks, over their uniforms when they enter the sterilisation/ clean workroom, in order to maintain the cleanliness of the space and to reinforce protocols for achieving acceptable levels of sterility in processing reusable products.

iii. Sterile storage

Sterile storage is generally adjacent, in an area with less traffic. It is common to rotate stock to avoid outdated sterilised products being used. Enclosed carts are often used for transport of these products in the hospital.

Cold sterilisation

Recycling expensive medical products made of plastics or latex that cannot survive steam sterilisation is typically accomplished through the use of gas or fluid sterilisation. Much has been written on the risks of this process and the need for through-venting and terminal aeration of products before reuse. This technology is well known and standards for correct application have been well established. The building design should support correct use of these techniques.

As with other hazardous exhaust air venting, must be accomplished well above the hospital and at a location where contamination of air used in the hospital and surrounding structures does not occur.

Aeration of gas sterilised products is accomplished by blowing air over the sterilised products in a sealed aeration chamber for a period of 24-48 hours.

This process is costly in two ways:

1) It requires power over a period of time and should be on emergency power for safety, and

2) The system presupposes that a large inventory, at least three days' supply of the parts or products, is owned by the hospital.

This is not a "flash" (quick) sterilisation process.

iv. Sub-sterile Room (optional)

In addition to the central sterile supply, in larger facilities it is common to provide a small room adjacent to each pair of operating rooms equipped with a washing area and a flash steriliser for heat sterilisation. This provision is essential for resterilising dropped instruments, and for resterilising, between surgeries, instruments that are in short supply.

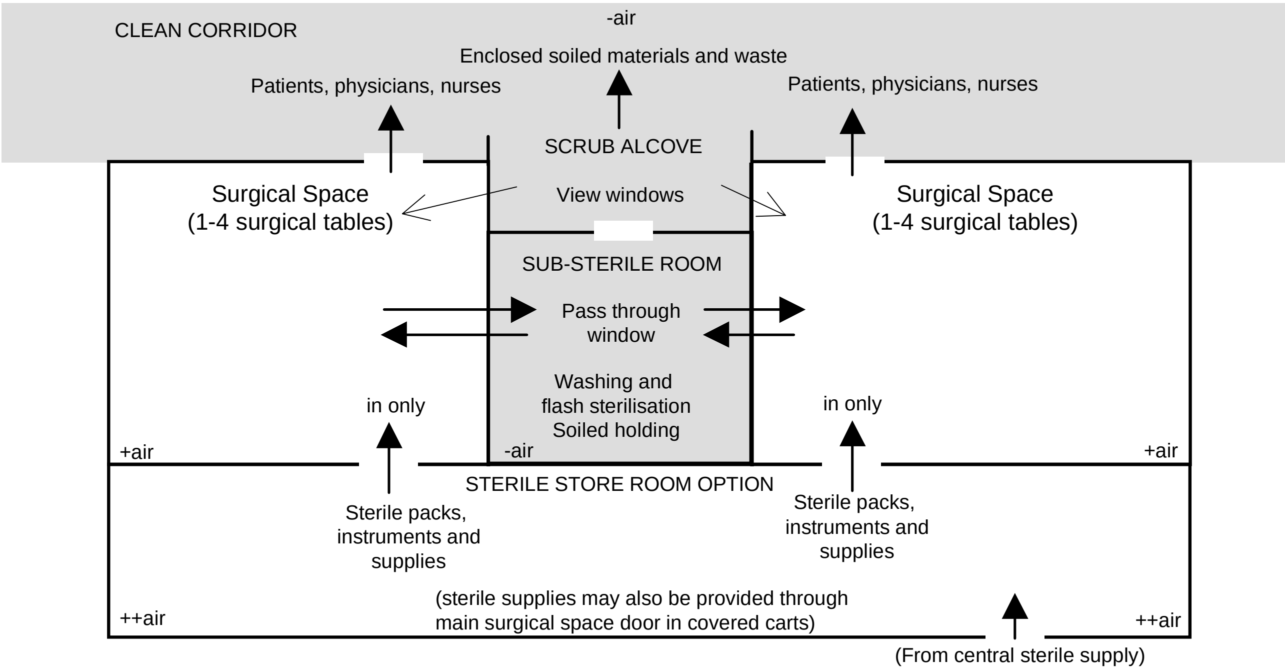
At Aravind Eye Hospital in Madurai, there is one sub-sterile room between every two operating theatres, comprised of an ultrasound washer and a flash steriliser, for reuse of materials and instruments in the operating theatre.

Many feel that the central sterile supply should be adjacent to the surgical space. This is certainly useful in small to medium-sized facilities. In very large facilities it becomes less meaningful.

Traditionally, surgical nurses performed many of the tasks in central sterile supply after the morning load of surgeries was complete. As surgical schedules have extended, central sterile supply has increasingly become the job of special technicians.

Floor Plan of Surgical Space

(Showing substerile room option and
one possible location for sterile store room option)



In 1991, before Lumbini built its own facility, the hospital was a stuccoed, one-storey building with the Eye Care Project attached to one side. There I learned that it is possible to do a very good job with minimal equipment and minimal resources.
The outpatient clinic consisted of one cavernous, dusty room open to the outside, with birds nesting by its high windows. In spite of the surroundings, up to 300 patients a day were examined. At the height of the day many patients would crowd into the room trying to attract the doctors' attention. Most of them, having traveled for several days, had come prepared with provisions to camp as needed. Some of the inpatients were housed in a small bamboo hut off the side of a courtyard, which also served as a waiting area.
The operating theatre was a small, darkened room. There were three beds and two operating microscopes. I scrubbed at a sink in another room, rinsing my hands with water poured directly from a teakettle. No gloves, but I had 'spirit' poured on my hands. This alcohol ablution was to be repeated between each patient, in lieu of a repeat scrub. I did the same operation I would have done in the U.S., implanting the same intraocular lens, but with only minimal technology... [...] Sometimes during that first morning the lights went out in the middle of a case. The circulating assistant immediately produced a flashlight, and held it in position, as I continued on, as though nothing was amiss. This would occur again several times throughout the day. There was only one generator for the hospital, and most of the time it was with the eye camp team, somewhere 'up in the hills.'
-Maura Santangelo,M.D.

2. Appropriate and sustainable technology

- Do we know for sure what technology we will need in order to provide large volume, high quality, cost effective cataract surgery?
- How much do we want to depend on "high tech" for our design and planning tools, and within our finished facility?
- What are the advantages and disadvantages to having a facility dependent on high technology?

Shun designing tightly around anticipated technology. As energy analyst, John Holdren, says to all futurists, "We overestimate technology in the short run and underestimate it in the long run." So design loose and generic around high tech. You will be wrong about what is coming, and whatever does come will soon change anyway.

- Stewart Brand

Technology has been defined as the ensemble of mechanical or scientific methods, products or systems invented for achieving human goals. Appropriate and sustainable technology reminds us to be aware of the consequences of our choices. It is an opportunity for problem-solving from the bottom up, using grassroots solutions to local problems. It considers that people struggling with their needs on a daily basis understand those needs better than anyone else, and can suggest or even invent the best technological solutions or innovations. Remember to look to your own experience, your own staff, your own locale, your own culture, your own situation for technological solutions to your needs.

At Aravind Eye Hospitals, the surgical microscopes are located between two operating tables to make it possible to swing the microscope from table to table, rather than duplicating this expensive instrument for every table. Thus when one patient is being prepped or sutured, the other patient may be undergoing surgery. Ophthalmic examination stations are paired so that two physicians can share each slit lamp.

In the United States, one hears a great deal about the goals of appropriate and sustainable technology, but hospitals and clinics there still use a disproportionate amount of energy and community resources compared to hospitals in other parts of the world. The U.S. model is not only expensive, but also potentially unreliable in places where energy shortages and power brownouts, blackouts and surges are common.

In many countries, where resources and energy are in short supply or very costly, building U.S. or European-style hospitals might restrict the number of patients who can be served. Hospitals practising sustainable design principles make better use of available resources.

Since buildings inevitably grow, it is handy to have the five directions (including up) that rectangular buildings offer for expansion. Right-angled shapes nest and tile with each other universally, so tables fit into corners, and clothes into closets, and buildings into city lots, and lots into city blocks.

- Stewart Brand

a. Flexibility and change

- Who should we ask for advice on future trends in technology in the eye care field?
- How can we ensure we are able to make changes without major upheaval?
- How can we plan now for future growth?
- How do we want to be able to adapt or expand our facility in the future?
- Where do we wish we had extra space now?

Allow for change and evolution in all aspects of your eye care programmes. Use building systems that are simply built and can be altered and augmented as

Appropriate technology is defined as technology that is best adapted to the conditions of a given situation, working with the cultural, human and natural elements of the situation, not merely the economic or technological ones.
- Adapted from 'Appropriate Technology Source Book,' 1993

needed. Provide a modest component of excess capacity throughout your facility, if possible, to avoid the need for costly renovations. For instance, a small amount of excess space in key treatment areas will frequently facilitate the inclusion of new equipment, students, visitors and volunteers.

At Aravind Eye Hospital in Madurai, service verandahs outside each room provide a pathway for services, simplifying the introduction of new equipment over time. A lot of the piping and plumbing is on outside walls, for easier and less disruptive maintenance and repair. This strategy will not work in cold climates, of course, where piping could freeze and break in winter.

Ophthalmologists and their patients will benefit most from equipment that functions well. Not that ophthalmologists should become technicians, but as in health care, the rule "prevention is better and cheaper than cure" is also valid here. It is important that all junior staff be trained in the proper handling and care of each instrument, to know the optimal quality of its functioning and how to recognise any faults.

- Prof. V. Srinivasan

b. Medical technology and technical supports

- Which medical technologies are necessary to support a large volume, high quality, cost effective cataract surgery programme?
- Which would be nice to have but are not necessary?
- What are the learning curves (the length and difficulty of learning) for these technologies?
- Are service personnel and parts available and reliable?
- Do we have access to a knowledgeable equipment consultant? Should we have one on staff?
- Have we ensured our surgical and diagnostic spaces are big enough and planned well enough to accommodate the equipment we want to put in them?

Your building should support the use of appropriate, up-to-date medical technology with needed space, structural supports, electrical services, communications lines, piped services and climate control. In planning the facility, locate equipment strategically to make it conveniently available for maximum use.

In many North American hospitals, service racks or shelves are provided overhead in the corridors. These racks are easily reached by service people with step ladders without entering diagnostic and treatment spaces.

It is wise during the planning process to engage a knowledgeable equipment consultant with biomedical engineering expertise to provide information on appropriate equipment. As an example, the number of electrical outlets in a room must be matched with the proposed equipment list, and double checked by the bio-engineering/equipment specialist. For instance, the x-ray room at your hospital should be designed based on the input given by the company, following safety guidelines (e.g., lead shield protection for the radiographer) prescribed by them. It is especially important to adapt choices to local availability of parts and service personnel.

At Aravind Eye Hospital in Madurai, a certificate course in Ophthalmic instrument Maintenance is offered. Their publication 'Ophthalmic Instruments and Equipment - A Handbook on Care and Maintenance' is very useful.

Fundamental equipment list

Operation theatre equipment:

- Operating microscope - for microsurgery
- Vitrectomy machine - for vitreous work
- YAG laser - for a surgical procedure in the treatment of glaucoma and for treating the posterior capsule opacification following Extra Capsular Cataract Extraction
- Autoclave - for sterilisation
- Other:

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Outpatient and refraction equipment:

- Slit lamp - to look at different parts of the eye in sections and at different depths
- Direct ophthalmoscope - to look into the eye (fundus)
- Indirect ophthalmoscope - to look into a greater area of the retina than what is possible with direct ophthalmoscope
- Fundus camera
- Refractometer - to measure the refractive error automatically
- A-scan - for measuring the axial length of the eye and for calculation of IOL power
- Keratometer - to measure the power of cornea, a factor needed for contact lens prescription; also for calculation of power of intraocular lens (IOL) used in cataract surgery
- Schiotz tonometer - to measure the pressure in the eye (IOP- intraocular pressure)
- Streak retinoscope - for objective evaluation of refractive error
- Other:

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The attraction of traditional materials is more than just aesthetic. Their whole use cycle is a highly evolved system of trade skills, reliable supply sources and routes, generations-deep familiarity, and even a market for reuse of durable materials such as slates, tiles, bricks, and timbers. The problems of traditional materials are thoroughly understood, and the solutions are equally well known.

- Stewart Brand

c. Sustainability

- How can we make our facility an example of sustainable development?
- What are the principles of sustainable development that apply to our facility?

- What building materials and methods, locally available, combine the best of durability with the best of adaptability?
- What aspects of design maximise our local opportunities for maintenance and upgrading? What aspects of our facilities cut down on long term costs for maintenance?

Sustainability has sometimes been defined as development with future generations in mind. In building construction, this translates into building with local renewable building products, using renewable sources of energy, practising energy conservation, recycling waste products, reusing materials and instruments, and so forth. What else does sustainable building construction include in your location?

Your hospital building should meet good building standards for structure, ventilation, air conditioning and heating, maintenance, ease of cleaning, and energy conservation. The building should respond appropriately to the climate and locale. Outdoor space should be integrated into the programme whenever possible. A reliable level of human comfort and air quality should be provided. Natural lighting, heating and cooling techniques (using natural, renewable energy sources) should be designed into the building, especially in situations of possible power or equipment failures. Local, renewable or recycled, nonpolluting, non-toxic materials should be used wherever possible to minimise initial and long term costs, dangers to construction workers, maintenance costs, energy costs, and damage to the environment. In many locations, renovating an existing building will be a choice that is both sustainable and economical.

Climate and site analysis includes wind, relative humidity, temperature, orientation for breeze, and shading projections.

For example, Northern Guatemala has a warm-humid tropical climate, which does not require heating. Because there is no electrical service in Las Cruces, mechanical space cooling is not feasible. This required the buildings to be designed for natural ventilation. Electricity for the operation of [surgical] lighting and equipment will be provided by generators on site. The building orientation chosen is that which offers maximum use of the prevailing breeze while minimising the exposure of exterior wall surface to direct sun light.

- C.W. Haynes and Prof. George Mann

Aravind Eye Hospital in Madurai, has been carefully designed to minimise energy use and maintenance costs, as well as first costs (initial costs of purchase). Ideas that have worked for Aravind in a hot climate with a dry season and a wet season include:

- Minimising imported materials that are subject to high duty in India
- Using local materials that clean easily and wear well such as a local gray stone flooring tile which continues to look handsome after 20 years of thrice daily mopping
- Using locally available paint products, even though they are not as longlasting as more expensive imported products. While this decision increases maintenance, it produces a pleasing freshly painted look, creates jobs, and may use fewer toxic substances.
- Shading windows with a breeze block verandah. (Breeze blocks are locally made and the verandahs provide housing and service access for utilities with minimal disruption to patient care.)
- Using the shape of the building to enhance comfort, e.g., a courtyard and single loaded verandah floor plan to give each room cross ventilation
- Limiting the use of mechanical air conditioning to a few priority areas: surgical spaces, several specialty clinics, deluxe suites available to paying patients, several guest rooms for foreign visitors who are not accustomed to the heat, and selected clinic areas where specialised equipment is in use
- Surrounding the building with an irrigated garden to cool the area at the base of the hospital (as well as to lay the dust), making air conditioning less essential
- Using locally made and repairable doors, windows and cabinets
- Using hasps and padlocks in place of more costly, less flexible cylinder door locks that require locksmithing skills to change
- Using heavy gauge materials that wear well

- Limiting dependence on emergency power by providing daylight in most spaces, but providing emergency generator capacity to support selected essential computer, medical and surgical functions (operating theatres, for instance) during frequent power cuts
- Building with common local techniques and indigenous building products to take advantage of local skills as well as materials: reinforced concrete frame filled in with plastered rough local brick; a local flat roofing system, such as a recipe of adobe (a building material of sun-dried earth or clay and straw) with jaggery, resin and other local products, topped with tile. (Each local 'recipe' has its own particular properties. Since indigenous building techniques and products vary by country and according to particular situations, check with local contractors or building technology researchers in universities, government agencies, or nongovernmental organisations.)
- Gathering roof runoff of rain water for treatment as drinking water by filtration and boiling (Potable water is provided to all patients.)
- Reuse and recycling of waste products such as paper, grey water (wash water that does not contain biological contaminants), rags, organic wastes from catering, burnable wastes usable as fuel, tin cans, bottles, disused medical equipment and office equipment and so on. What other waste products in your eye care facility can you reuse or recycle?

The human comfort zone varies with temperature, humidity, air movement, clothing, acclimatisation, and level of physical activity. This information has many important [building] design implications in areas where cooling is required. These guidelines vary with the climate:

A. Hot-arid climate:

1. Take advantage of the broad daily temperature variation by using materials that absorb the day's heat for reradiation at night and by trapping and holding cool night air.

2. Have plenty of shading.

3. Minimise daytime ventilation.

B. Hot-humid climate:

1. Site, orient and construct the [building] to take maximum advantage of natural ventilation.

2. Use light weight non-heat absorbing materials.

3. Supply adequate shading.

- Adapted from John S. Taylor, from Commonsense Architecture: A Cross-Cultural Survey of Practical Design Priniciples

The overall environment is one of frugality, comfort, and support for excellent medical care. Aravind Eye Hospital's high quality medical environment uses very little energy per square metre or per patient compared to U.S. and European examples, including examples in much less severe climates.

In a different locality or climate, the particulars would be different, but the principles still include using proven local solutions, "life cycle costing" or balancing frugality with lasting quality, and exercising care in the use of high energy-using systems such as air conditioning, in favour of using the building itself to produce comfort passively. Building shape, orientation and materials can significantly contribute to comfort in the interior environment and reduce or eliminate the need for mechanical heating, cooling and ventilation. Much can be learned by finding local buildings that are unusually comfortable with little expenditure of energy. Unfortunately, in many localities the advent of modern, fireproof construction has almost eliminated traditional, climate-adapted structures.

Desirable building features will differ significantly depending on the amount of the year that is above or below the comfort zone. Relevant features may include:

- Tree planting for shade
- Other shading
- Cross ventilation
- Building orientation
- Passive solar heating
- Night sky cooling
- Insulation
- Daylighting

Good climate information is essential for optimising building performance from the viewpoint of comfort. While a cold climate will demand a compact building protected from winds, a hot and humid climate will suggest the use of slender, well-shaded wings exposed to breezes. Insect screening is desirable in most climates.

In Taiwan, most new hospitals and clinics are intensely air conditioned year round, yet some of the 100-year old portions of National Taiwan University Hospital are fairly comfortable most of the year, even without air conditioning, due to:

- **Natural, flow-through ventilation (the wings are one room deep)**
- **Climate appropriate orientation: the wings run east - west and openings on the north and south are easily shaded with a small overhang**
- **Dense vegetation providing shading on walls and windows**
- **Daylighted spaces requiring little electric lighting, which can add heat as well as cost**
- **Louvered shutters darkening rooms when needed, such as during an early afternoon nap break**
- **High ceilings allowing for ceiling fans and greater cross ventilation, as well as greater internal volume to dissipate internal heat loads.**

It is not unusual to reduce heating and cooling needs to one half or less through the use of sustainability principles and design features. In the U.S., the state of California has taken leadership in this area by providing standards and calculation procedures for 18 micro-climates within the state. While experts dispute the detail, it is clear that new construction is much more comfortable with less added energy.

In hospitals and clinics, this effect has been less dramatic due to the practice of using a high number of air changes each hour and exhausting all used air rather than recycling it. It is not uncommon for new structures to use more energy than old ones. This has been particularly true where new structures introduce new standards of comfort and a central environmental control system for the first time. The cost of operating these systems is high. Generally, it is wise to consider mechanical ventilation, cooling, and heating only as a backup to natural sustainable systems, which work to provide human comfort passively and inexpensively. Where reliability and availability of repair parts and power are issues, it is essential to consider passive cooling and ventilation, and passive solar heating as the primary systems. In some parts of the world, there are many portions of a building that will seldom need the mechanical backup systems.

No room ought to be without a window, by which the enclosed air may be let out and renewed, because else it will corrupt and grow unwholesome... The windows will be best contrived for admitting the sun if they are made large, and yet may avoid being troubled by the winds at the same time if we place them high, so that the cold air may not blow directly upon the people within. Lastly, from whatever side we take in the light, we ought to make such an opening for it as may always give us free sight of the sky, and the top of the opening ought never to be too low, because we are to see the light with our eyes and not with our heels.

- Leon Battista Alberti, 'De re aedificatoria,' 1485

At Columbus School in California, small systems for each classroom replaced the usual central unit. These units are simple, high quality, mass-produced and standard, not custom units. Parts are available locally. By keeping mechanical systems simple, first costs were about half of a central system, and the system is flexible, easy to maintain, and uses less energy. How does this work?

- **Anyone can fix these units, since they are standard, not custom units, and parts are available locally.**
- **These manufactured units are well tested compared to custom units and tend to break down less.**
- **The units have been refined to use energy more efficiently than most custom units.**
- **There is literally no transmission loss of energy as the units are at the point of need.**
- **Each classroom has a thermostat and can be activated individually; if only one classroom is used in the evening, then only that classroom needs to be heated (or cooled, in a different season or climate).**
- **Special filtration can be introduced where needed; one classroom can be equipped with better filters (at some loss of efficiency) for asthmatic or allergic students.**
- **A breakdown is limited to one classroom, and does not affect the whole system.**
- **Temperature can be adjusted to the need; the exercise class can turn down the**

thermostat rather that throwing open the windows in mid-winter.
- The whole campus was planned using principles of passive solar design and daylighting, to minimise reliance on non-renewable energy sources.

A similar principle is in use at Aravind Eye Hospitals in Madurai and Tirunelveli, where room air conditioners can be removed and substituted with reconditioned and sanitised units as needed. Thus a malfunctioning unit can theoretically be substituted with another unit from a service balcony in minutes, with the major delay being the cleaning process to safeguard the hygienic nature of the space. (There is considerable ongoing discussion about the best manner to sanitise individual air conditioning units to prevent contamination, as units are seldom designed with ease of cleaning in mind.)

3. Function

The hospital building must be designed to help staff work effectively and efficiently. It should facilitate the eye care programme as envisioned and developed by eye care staff. It can be designed to promote a large volume, high quality, cost effective cataract surgery programme. While functional spaces cannot make a poor staff perform well, they can support rather than impede good practices.

a. Form follows function

- Are we clear about our function?
- What services do we want to provide in our eye care facility?
- What types of patients do we want to attract?
- How many patients do we want to care for?
  - in the outpatient department?
  - in our surgical spaces?
- How can we plan or redesign the building to suit our needs, and the needs of our patients, rather than adjusting our work habits and moods to the building?

Well planned facilities in the operation theatre and good supportive paramedical people can help a surgeon to do 2000 cataract surgeries a year, while now most of the eye surgeons [in India] do fewer than 300 cataracts a year.

- Dr. G. Venkataswamy, Aravind Eye Hospitals

Your hospital building should not stand in the way of staff efficiency and effectiveness. The building should support good medical practices, such as frequent hand washing. The building design should allow easy rewiring and repairs, with electrical wires for equipment placed in dropped ceilings, for example. Adequate light, power and other services should be provided at point of use, where they are needed.

Adjoining and adjacent spaces should be planned to support good patient flow and visual supervision. Space should be carefully allocated where needed for effective patient care, and not wasted. Spaces should be easy to maintain in a visibly clean and attractive condition. Colour selection should aim to support the use of the facility by the visually impaired and the elderly. Stairways and corridors should be wide enough to allow patients, with their attendants, and staff to move at their own pace. Avoid steep staircases.

At Aravind Eye Hospital in Madurai, India, the free hospital was built with wide, sloping walkways (long ramps) to allow elderly and handicapped patients to walk independently from one floor to another, with room for faster individuals to pass.

Before planning the hospital or clinic layout, give sufficient thought and care to planning separate outpatient registration and inquiry counters, for both new and review cases separately.

- Mr. G. Srinivasan, Aravind Eye Hospitals

b. Make a clear functional layout

- How do we want to see our patients? Should we move to them? Or should they move to us?
- To the extent possible are we able to map out the resources and structures for provision of eye care in our region?
- Can we design our hospital to be integrated into the entire region?
- Is it desirable to design the structure for provision of eye care in our region with future development in mind?
- Do we even need a permanent site (base hospital)? Would a mobile eye hospital be more effective in our situation?
- Could we rent space and turn it into an efficient and effective eye hospital with the appropriate layout?

Health care institutions must take care to avoid dehumanising the process of medical care, while remembering that seeing more patients effectively and efficiently is, of course, humane. When many patients are seen by few skilled practitioners, approaches such as assembly line principles should be considered. Taylor and other early industrial rationalists did time and motion studies to develop a reasonable pace and to decide how many workers to assign to each step in the process.

It impressed me completely at Lumbini Eye Hospital how they utilise every square inch of the place, and how patient flow from one room to the next was improved throughout with efficiencies.

- Sandi Smith

For instance, at L.V. Prasad Eye Institute, patients are stationary and clinicians go from one diagnostic and treatment room to the next to see each patient. In other facilities, patients move from station to station for different tests and procedures.

At Aravind Eye Hospital in Madurai, principles of industrial efficiency have been employed to organise a clear diagnostic and treatment sequence with the most common procedures at the beginning and rare and optional procedures toward the end of the screening process:

A. Registration, medical records, and waiting

B. Preliminary screening: Snellen charts (in English, Tamil and graphic forms) and initial screening by ophthalmic nurses with minor waiting

C. Primary clinics: screening and treatment by ophthalmologists for basic problems with medium-sized waiting area and adjacent minor treatment station, and office and secretary for senior medical officer (may be several clusters in a large facility; at Aravind-Madurai, there are 3 clusters - Units I, II and III)

D. Refraction units: refraction lanes with medium-sized waiting area, nurses provide the bulk of care. At Aravind-Madurai, there are a total of 5 refraction clusters:
  - three in the primary clinics - a refraction unit attached to every primary clinic cluster (D I, D II and D III);
  - one in the paediatric clinic;
  - one for all the other speciality clinics together.

E. IF NEEDED, optical dispensary: frame selection, lens grinding, eye glasses fitting and sales

F. IF NEEDED, pharmacy: pharmaceutical dispensary that provides optical pharmaceuticals and other common compounds, with minor waiting area shared with lobby

G. Specialty clinics such as paediatrics, retinal care, etc., which are visited by fewer patients and may be located more remotely from the lobby, with their own waiting areas

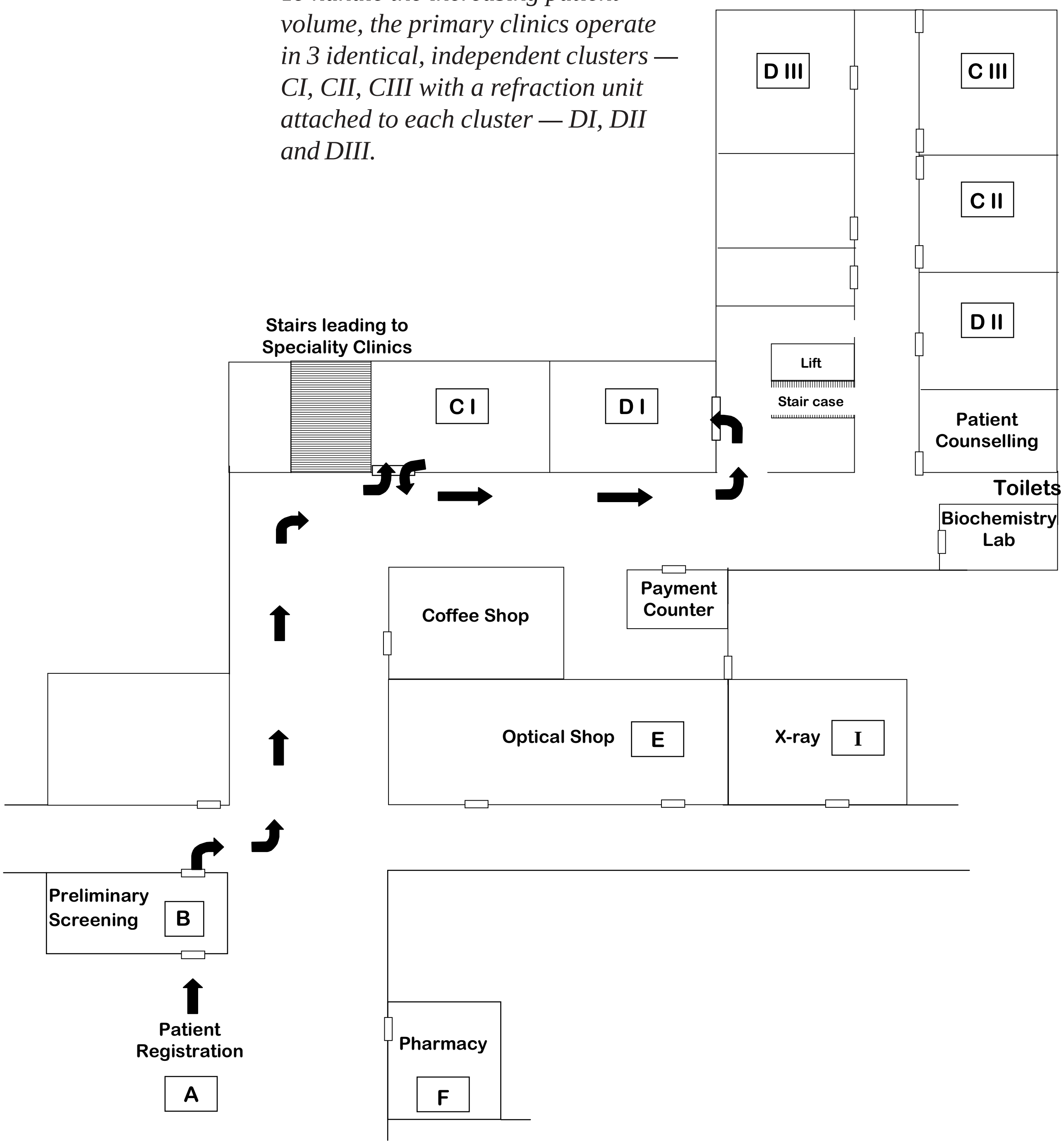
H. A second payment counter for lab tests and x-rays

I. X-ray department

In actual practice, the floor plan may not be a straight line. It may surround a courtyard. It may even be on more than one floor, although location of at least (A) through (F) on the same floor is convenient. As the programme develops and adjusts within a clinic space, it can make patient navigation easier with a few well placed signs and other indicators such as wall texture and vivid colour for the visually impaired.

Aravind-Madurai: Ground Floor Plan

To handle the increasing patient volume, the primary clinics operate in 3 identical, independent clusters — CI, CII, CIII with a refraction unit attached to each cluster — DI, DII and DIII.



My most rewarding project was the development of a "portable refraction booth" for use in mobile screening eye clinics. The refraction booth is a closet-sized cubicle assembled out of a plastic tubing frame with a cloth fitted over it to allow light control for eye examinations.

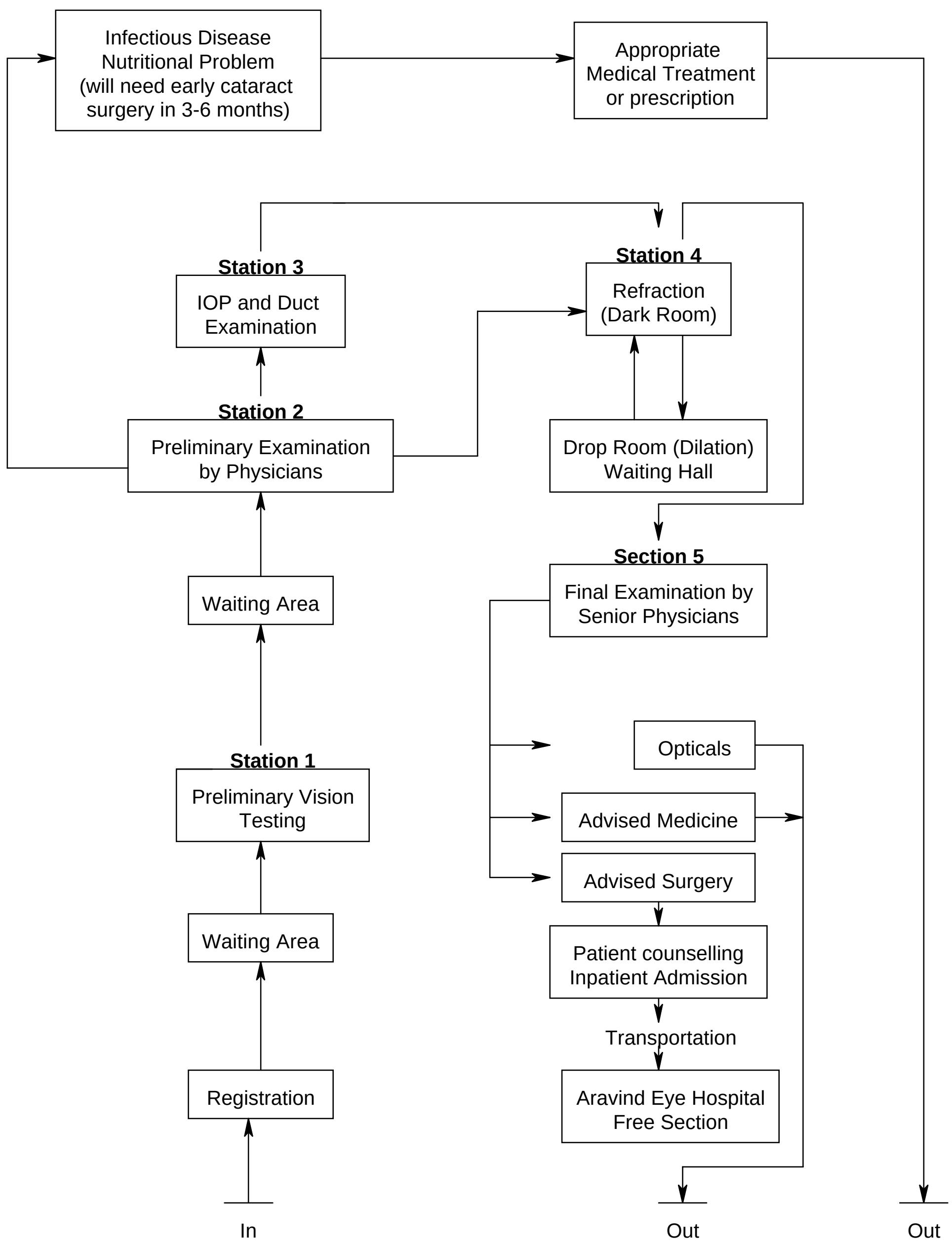
- Dr. Peter Rae

Screening Eye Camp Procedure

Temporary eye camps for screening and surgery can follow many of the same design features. At a screening (diagnostic) camp the ophthalmic medical team examines the patients for eye problems and treats minor problems on the spot. People who need surgery or specialty care are advised to go to the base hospital. Surgery is not performed at a screening camp.

At an outreach surgery camp, patients are examined for eye problems and the necessary surgery is then performed at the camp itself. Surgical eye camps are difficult as well as highly expensive to conduct in rural and rustic areas due to lack of proper facilities. However, when effectively designed and efficiently set up, outreach surgery camps can be very successful.

Screening Eye Camp Layout



Pratistha Eye Camp, in Raipur, Madhya Pradesh, India, conducted 5,104 cataract operations in 17 days. Four operation theatres were established, each with two rooms to prevent cross infections. Each room had three tables, one senior surgeon, two assistant surgeons, one anaesthetist, four paramedicals and eight volunteers. In total, 24 operation tables were at work daily.

A complete equipment list for screening eye camps is provided in the Community Outreach Module.

c. Functional requirements and design criteria

- What can we compromise, and what can we not afford to compromise in the design? What are all the "costs" of compromise?
- What trade-offs are acceptable?
- Do some design criteria contain added benefits?
- Do some design criteria contain hidden costs?

At Aravind Eye Hospital in Tirunelveli, we integrated the operating theatres of the paying and free hospitals for economies of scale. In order to better utilise operating room capacity, we have a central surgical facility which the free and paying sections of the hospital jointly utilise.

- Dr. R. D. Ravindran

The most important component of an eye hospital is the operating theatre, not the number of beds. Put everything into your operating theatre.

- Dr. G.N. Rao, L.V. Prasad Eye Institute

For surgical spaces:

- Maximise use of costly ophthalmic surgical equipment and operating theatres
- Provide adequate light where needed to support surgical accuracy
- Maintain a very high level of cleanliness
- Organise the process to support paramedical involvement in order to extend the capabilities of surgeons
- Support and train staff to help them work effectively
- Create a logical and dignified flow of patients through the surgical area that supports clear visual supervision of patients at all times
- Organise the flow to support minimum anaesthetic use consistent with pain control and conditioning the eye for surgery
- Maintain a positive air pressure in the surgical spaces to limit the spill of soiled air from surrounding spaces into the surgical spaces.

At Aravind Eye Hospital in Madurai, the benefits of the twin operating table model include sharing the microscope (which is expensive) and providing M.D. supervision for increased paramedical participation and resident training.
At Aravind Eye Hospital in Coimbatore, the free and main hospitals share a scrub area and a sterilisation area.

For diagnostic and treatment spaces:

- Maximise effective patient visits
- Support patient and family education and dignity
- Support and train staff to help them work effectively
- Make efficient use of costly diagnostic and treatment equipment
- Maximise care given to the overall community

For patient bedroom spaces:

- Allow for appropriate, accurate medical care
- Provide some privacy, dignity
- Allow family support

Unlike the main hospital, patients in the free hospital did not have 'beds' in which to recuperate and recover, but rather were taken to big rooms on the upper floors and each was provided with a 6' x 3' bamboo/coir mat, which was spread out on the floor as a bed, and a small-sized pillow. There were several such rooms, each accommodating 20 to 30 patients. Each room had self-contained bathroom facilities. People from the same or nearby villages were usually accommodated in the same room. They moved together as a cohort, both before and after surgery.

- 'The Aravind Eye Hospital, Madurai, India: In Service for Sight' V. Kasturi Rangan, Harvard Business School, 1993

- Provide for spiritual support
- Arrange for food service
- Facilitate staff support
- Provide patient and family education
- De-institutionalise and humanise the hospital as much as possible while providing excellent technical care and medical supervision

d. Waiting is part of the process

- Who waits? How long?
- What is the pattern of waiting? What are the advantages? What are the disadvantages?
- Do we want to improve our waiting situation?
  If so, what changes will facilitate large volume, high quality, sustainable cataract surgery?
- Are there ways to make waiting educational for the patients or beneficial to their health?
- Are there ways to make waiting profitable? for the patient? for the eye care facility?

Waiting is viewed differently by different people. If staff are forced to wait, it is a waste of their time and the hospital's money. A well-to-do urban person who arrives in a private car on a brief break in the middle of a work day will view waiting differently than a villager who arrives at the end of a long bus journey. The professional may be frustrated by waiting times, while for the labourer, except for medical anxieties, waiting might be almost acceptable.

Sometimes the local pattern of life or transport system will affect scheduling options and result in large numbers appearing at once, necessitating additional waiting. Space must be provided to accommodate expected patient flow.

At Aravind Eye Hospital in Madurai, most patients arrive first thing in the morning when the daily buses from outlying towns and villages arrive at the nearby regional bus station. Similarly buses from eye camps arrive with large numbers of patients for the free hospital.

- **The ample forecourt to the hospital serves as a staging area to redirect patients once they arrive. Perhaps because of this huge influx, local patients also seem to arrive simultaneously to obtain a place in the queue. Early mornings are extremely busy, if orderly, and waits are very long by American or European standards.**
- **Physicians and surgeons seldom wait. They see a large number of patients each day. Afternoons are quiet in screening/primary care and busy in the specialty/referral clinics.**
- **While the disadvantage of this uneven pattern of activity is that much of the facility is largely empty for many hours of the normal work day, the good side of this pattern is that the day has a rhythm to it that permits the exceptions in life: a grandchild visits a grandmother, cleaning and maintenance is accomplished, on-the-job training can occur, and so forth.**

Combining many waiting areas can sometimes result in minor economies in space use, but at some cost. Except in smaller clinics, it is beneficial to locate waiting near the professional staff so that they don't have to wait between patients. Decentralised waiting can also contribute to an atmosphere of quiet professionalism and avoid the overwhelming feeling that the sight of many waiting patients can produce in staff and patients alike.

At Aravind Eye Hospital in Madurai, waiting is decentralised. Each set of rooms for ophthalmic service has a medium-sized waiting area, which assists in keeping a clear flow and sense of progression for patients and families. Each station is a small work group that can be easily overseen for quality control and supervision. The impression created is one of quiet and competence.

It is particularly important to decentralise waiting for septic cases and for paediatric care. In some cultures, different social, ethnic, economic or gender groups might need separate waiting areas or schedules.

4. Response to social context/community design

More foreign architects are traveling to developing nations for consultations. Unfortunately, many of these foreign architects provide little help. They recommend expensive facilities without first properly analysing the healthcare problems of the people. Examining the needs of a community before constructing new facilities or additions makes sense in poorer countries as well as wealthy ones.

- George Mann

"Cultural fit" is an important aspect of planning a new or redesigned eye care facility. It must respect and support local social, cultural and spiritual practices and patterns. The "built environment" must be arranged to appropriately support the dignity and effective participation of everyone involved in large volume, high quality, sustainable cataract surgery programmes.

a. Support local patterns of life

- Is our hospital a good fit with the local patterns of life?
- Does our hospital respect and accommodate all local ideologies?

The history of architecture contains many examples where ideas have been successfully transplanted from one culture to another. It also contains many examples of the opposite.

An American clinic layout (where patients have precise times for their 20 minute appointments with physicians) did not work in Taipei, Taiwan, where all the patients for the day, scheduled and unscheduled, appear at opening time to queue for their five minutes on the physicians' schedules.

A lot depends on your audience. You must get to know it, perhaps through marketing surveys. For example, in an industrial town, people want to get back to work quickly, so there is not a lot of need for expensive, air-conditioned patient suites.

- Mr. G. Srinivasan

Respect for and response to local social, cultural and spiritual practices and patterns is essential in developing useful buildings that appropriately support the dignity and effective participation of patients, their families, medical staff, paramedical staff, other professionals, volunteers, support staff, administration, and others.

In thinking about cultural issues it is useful to imagine and investigate the responses of:

- Women and men
- Children, young adults, middle aged, and elderly
- Well educated and uneducated
- Urban and rural
- Blind, sighted and visually impaired
- Chronically ill, acutely ill and healthy patients
- Patients requiring routine refractions, diagnostic tests, or complex treatments
- Rich, poor and in-between
- All religions and faiths in the region

and so forth. Don't forget to ask for the opinions and suggestions of staff members and volunteers, from cleaners to senior medical officer, librarian to chair of the board.

Options for maintaining normal daily and weekly patterns of life during illness can be strengthening to patients and their families.

Spiritual Practices

Meditation spaces and other support facilities that permit spiritual practice are very welcome.

At Aravind Eye Hospital, in Madurai, quiet, light, attractive meditation space is provided. Fresh flowers welcome the visitor. Within the hospital neighbourhood, other ritual sites are evident that accommodate a variety of spiritual practices. Vendors near the hospital door provide common articles for ritual practices.

A garden can provide a calming, attractive place for meditation, escape from the bustle of the hospital itself, and needed contact with nature. Claire Cooper Marcus writes (in her book on Healing Gardens) of the importance of green landscaped gardens for patient, family and staff stress reduction, pointing out that in short stay facilities, the greatest benefit might be for staff. Measurable reductions in blood pressure have been observed, along with other less quantifiable benefits. New U.S. standards for general hospitals will make access to nature and gardens a requirement for certification. These gardens can vary from naturalistic places to soft flowery gardens to austere sculptural places.

At Aravind Eye Hospitals, open courtyards within the hospital buildings allow landscaped gardens, lily ponds or fish tanks to add natural beauty.

Beautiful outdoor space should be integrated into the facility wherever possible, and into the programme whenever possible. Be sure to list and provide detail for needed outdoor spaces in your development process.

A demonstration garden or self-guided kitchen garden on the hospital property can promote healthful, vitamin A-rich vegetables. Signs along the paths can teach cultivation methods.

Caution: This can be an area where infections are picked up, so use it as a waiting/teaching area for patients' attenders. (Vegetables from the garden can supply the hospital's canteen with fresh foods.)

Food

Other normal daily patterns take on new meaning at times of illness. Familiar foods, correctly prepared, are particularly welcome. While money can be very scarce, good nutrition may be a medical necessity. Health care providers often find it beneficial to maintain inexpensive canteens for patients. Institutions that do not provide food often have serious problems with insects and vermin due to variable self-service catering practices by patients and their families. Hygienic disposal of food wastes is more effectively managed if the hospital manages food service. In most cases, some allocation of space is needed to provide appropriate, palatable, nutritious, affordable food, which will benefit staff as well as patients.

At Aravind Eye Hospital, in Madurai, a range of food service options is available, including hospital run canteens, tray service for hospitalised patients on stainless steel thalis (round trays), a range of private food stalls and small cafés at or near the hospital door, and, of course, "tiffin" carriers, stainless steel lunch boxes brought by visitors and by messenger for local patients and staff. Food wastes are collected regularly and appropriately disposed of, largely through recycling. Little is wasted.

In many Kaiser hospitals in the U.S., space is in short supply and catering has been relocated to an off-site kitchen or even contract caterers.

In Tamil Nadu, as in many parts of the world, tap water is not safe to drink and bottled water is prohibitively expensive. At Aravind Eye Hospitals, potable water is provided throughout the facility in large stainless steel tanks with faucets. Patients share a single chained cup with admirable skill, as even children can drink without the cup touching their lips.

b. Community and privacy

- Which activities should be private? not private? gender segregated?
- What does privacy mean? Is it visual, olfactory, acoustic, tactile (sight, smell, sound, touch)?
- How can health procedures be made more open in order to contribute to health education and remove some fears of what happens "behind closed doors" and yet provide suitable privacy to support human dignity?

At Aravind Eye Hospitals, clinics are fairly open. In the paying hospital, waiting patients of both sexes can see the procedures being performed on others (fully clothed, of course) ahead of them in the queue. Most examining rooms are shared by two physicians. The exam rooms have open doors, which also close. Patients are seldom isolated. Ophthalmic surgeons can use their doors to examine a patient in private. In the non-paying hospital, low partitions substitute for walls with doors and it offers less privacy. Yet patients sit quietly and appear to grant each other some privacy.

Hygiene

Toileting and personal hygiene are important parts of daily living that involve special consideration in a group situation to support human dignity.

At Aravind Eye Hospitals, simple British Standard sanitary facilities are available throughout the hospital. These facilities are typically not near inhabited spaces such as waiting areas or offices and, although well-serviced, ventilate directly to the out-of-doors to accommodate possible odours. Senior staff and private patients have their own facilities adjoining their offices and private sleeping accommodations.

At Lumbini Eye Hospital in Nepal, care was taken to locate public toilets downwind of patient care areas, an advisable precaution due to sewerage and maintenance problems.

Here in hot southern India, our free patients sleep quite comfortably on mats on the floor. But in the north, where nights can get very cold, patients must sleep on cots with blankets in order to stay warm.

- R. Priya

I believe that "family centred care" has a great future. . . especially if it can be adopted in [countries] where family has such a large role to play in a person's life . . . and especially in paediatric care and care for the elderly.

- Sujayanthi Dasgupta

Sleep

For some, the first time they sleep alone or with strangers is in the hospital. This can be disturbing for patients. It is important to consider how close together people can be and still feel comfortable, especially amongst strangers.

Is sleeping private? communal? or at least familial? How does climate affect sleeping patterns? Is ventilation sought or avoided? Are beds, cots, futons, mats, rugs, or other types of sleeping surfaces employed? At many hospitals, several choices in sleeping accommodations are available to paying patients.

c. Care-by-kin

- How does our design accommodate traditional customs of family involve ment in health care?

Most people feel more comfortable with family and friends nearby. When the patient returns home, the family will support that patient's recovery. Training and education in the health facility can speed recovery, prevent complications and lead to timely referral of other patients. Often kin can perform chores that staff would otherwise be employed to perform.

If you are an adult it can be really frightening to be sick and alone with strangers. For children, it is even worse. The home language may be different than the public or eye care language. Often the child will fear abandonment and mutilation. Every effort should be made to allow a parent or relative to accompany the child through the diagnostic and treatment process, of course, but also in surgery prep, surgery, surgery recovery and the wards. Certainly a calm child will be easier for staff to treat and will recover from the experience with fewer worries. In most of the world, parents are expected to accompany children in the hospital and provide a portion of the nursing. Most cultures do this naturally.

While care-by-kin has many advantages, nonetheless it is the topic of ongoing debate among health care providers as to when and where to employ care-by-kin. Some argue that the accommodation, food and care required by family can create an extra burden on the already busy staff. Others argue that family participation is so culturally essential, excluding kin is unimaginable. Almost everyone advocates care-by-kin in the case of a terminally ill patient and for the hospitalised child.

If care-by-kin is the preferred pattern in your community, then it is critical to provide accommodations for SLEEPING, EATING, PERSONAL HYGIENE and EDUCATION of the kin. Space must be allocated, however small.


Patient bedrooms allowing care by kin

If sleeping accommodations are meagre and uncomfortable, the sleep-deprived relatives may be a burden on staff. In many cases, simple sleeping accommodations for relatives will relieve the night nursing staff of some of their routine duties. If the bed can fold up, roll up or stack to take little space during the day, little space must be added for this.

Visitors and patients will benefit if toilet and hand washing facilities are available and accessible. A family member may lack skill in infection control protocols and may omit the hand washing, so consideration must be given to who shares facilities with whom.

Provisions for food must be made to prevent casual storage of food stuffs, which may attract insects and rodents and/or harbour infection.

At Lumbini Eye Hospital in Nepal, camping facilities for families have been provided near the hospital, with outdoor kitchens and toilets. The increased access to families and their free time during hospitalisation provides a chance for health education. Families can be trained to recognise problems that require care and to administer simple treatments.

5. Beauty

Not everything that counts can be counted.

- Dr. Denis Burkit

What a shame to regain one's eyesight—and have nothing beautiful to see! The eye should have items of interest to observe in the eye care facility. Colour, texture and form should all handsomely affirm the importance of improved eyesight.

Traditional materials are considered aesthetic partly because of their rich texture but even more because they are thought to age attractively.

- Stewart Brand

a. Celebrate eyesight

- What are our cultural beliefs about beauty?
- What forms and colours and textures are traditionally regarded as beautiful to the people of this region?
- What aspects of the natural world are considered important for their beauty and healing properties, and can be represented in our facility?

The eye should have something to appreciate in an eye care facility. Local artists and crafts can embellish public places. This may be especially appreciated in spaces where patients and visitors will spend time, such as waiting rooms and patient bedrooms. Consider the use of textured surfaces for the minimally sighted and blind. Use colour boldly, but with consideration for differing levels of optical competence. Consider the use of colours and shapes that can be appreciated in different ways by people with differing visual acuity – more vibrant and higher in contrast for the partially sighted, possibly overlaid with a more subtle layer of detail to engage the seeing eye during longer periods of waiting and to confirm improvement in vision for patients whose treatment has been successful. Celebrate eyesight!

The senses tell us about what is important in our surroundings; mostly, we experience things through the outer senses: sight, smell, taste, sound, warmth, touch. Architecture in the sense of environmental design is the art of nourishing these senses.

Most of us do not go around deliberately touching buildings, yet without thinking about it we touch them all the time. Textures, which we walk on or feel with our hands (or eyes), make all the difference between places which are approachable and places which are not.

- Christopher Day, in Places of the Soul, Architecture and Environmental Design as a Healing Art

At Kaiser Hospitals in the United States, local photographs, prints and textiles have been used in the décor. A small portion of the construction budget is employed in building an arts collection. Pieces are not costly, but are well-made and selected with the aid of people knowledgeable in the arts, from the work of local artists. Plants and flowers grace the entries and courtyards.

Ricardo Legorreta, a Mexican architect, is famous for showing how the use of brilliant colour can enhance a very plain economical structure and give it unusual vitality.

At Aravind Eye Hospitals, a landscaped garden is maintained with a lily pond or a fish tank, making the hospital a pleasant place to come to. Local handicrafts grace the walls

Consider the site and its buildings as a single living ecosystem. Leave those areas that are the most precious, beautiful, comfortable and healthy as they are, and build new structures in those parts of the site which are least pleasant now.

- Christopher Alexander et al

b. Site repair

- How can we maximise the beautiful features of the building site, at low cost?
- How can we design beauty and function together as aspects of the site?

A hospital can both fit in and be distinguished from surrounding community buildings. Every building project presents the opportunity to create useful, handsome places where none existed before. The building site ought to be more beautiful after construction of the eye care facility than before. Builders often seek out beautiful spots and replace them with buildings. The option suggested here is a way to make a major contribution to the community while building, often on less costly land. Buildings should be built on the parts of the site that are in the worst condition, not the best.

When Aravind Eye Hospital in Madurai, India was originally built, the land it was on was less costly wasteland on the periphery of the city. It has now, of course, been surrounded by urbanisation and has significantly gained in value.

6. Economic Issues

a. Hotel care and medical care

- What are the cultural and economic values we must consider in our design of patient bedroom spaces?
- To what extent, based on the differing values within our community, would we provide different standards of accommodation?
- For what purposes?
- To what extent can we compromise?
- What is the bottom line standard for the accommodation we will provide, based on both health outcomes and societal values?

This two-tiered health care system doesn't seem ideal, but the following analogy helped me understand it. Airline passengers have a choice of economy class or business class when they book their flights. Although those in business class have paid more to have comfortable seats, gourmet food and more peace and quiet, all the passengers benefit from the same safety features and will arrive at their destination at the same time.

- Seva Volunteer from Canada

Many clinics and hospitals serve highly diverse populations. The physical environment can support and enhance the prestige of individuals, groups, and the eye care facility itself, but in different ways in different cultures. In many communities, at least some space must be "spent ceremoniously" to enhance prestige. In other communities, the parsimony (thriftiness or frugality) in space use might enhance community respect for the dedication of the physicians, surgeons, nurses and administrators.

To some, it is regrettable that the same type of care cannot be provided to all patients, especially since this creates duplication and wastes resources. In many countries, however, a difference in amenities is cultural, economic, even spiritual. Where it means that poorer patients will receive eye care despite their inability to pay for it, a two-tiered system becomes more palatable. The key to creating "service differentiation" (a difference perceived, perhaps unconsciously, by the patient) is to base the service that patients receive on their own living conditions, as a reflection of their economic status. Hence, patients who sleep on the floor at home will be comfortable sleeping on floor mats in the hospital. Those with privacy and air conditioning at home will expect both in the hospital. It is then more tactful and dignified to separate patients who are receiving different standards of "hotel care."

Differences in hotel care and catering can be accommodated and charged for. These extra charges can then fund cataract surgery for non-paying patients, who receive the same standard of medical care. (See the Financial Sustainability Module for more information.)

At Aravind Eye Hospital in India

- **Each paying patient may cover the treatment of two non-paying patients. The higher paying patients are treated in private or semi-private rooms with hotel-style accommodation, air conditioning and higher quality catering. The non-paying patients are treated in large dormitories with mats on the floor, modest food, and ceiling fans.**
- **While multiple levels of hotel service are provided, medical service aims at applying consistent standards. This has led to two side-by-side hospitals sharing many specialist facilities and staff rotation between the paying hospital and the free hospital.**

- **If paying patients perceive little or no difference in the product or service they receive, some will question why they should pay when others do not. In Tirunelveli, the intermingling of different populations for pre-op preparation is thought to have led to a reduction in paying patients and thus reduced funding for free patients as well.**

b. Outpatient care

- What are the benefits and advantages of outpatient care compared to inpatient care in our own context?
- What are the costs and disadvantages of each in our context? Do we have a clear picture of how our facility is integrated into the entire region?
- Are we being influenced by experiences that are relevant to our situation?

It is the number of surgeries that counts, not the number of beds. L.V. Prasad Eye Institute's goal is 20,000 surgeries in year 2000 with only 20 beds.

- Dr. G.N. Rao

In recent years, a strong movement toward outpatient (ambulatory) care, even for surgical treatments, has been experienced, especially in urban centres and especially where the patient's home is nearby, clean and uncrowded, and suitable care givers are present in the home.

Advantages of outpatient surgery

Hospital care removes patients from the home at a time when they may particularly value the support of their family and friends. Hospital care is generally more expensive for the patient and the facility than outpatient or home care. Hospital care may expose patients to hospital-borne diseases. Outpatient surgery encourages departments to run extremely efficiently. Hospitals can charge a high price to patients who want the convenience of day surgery.

Disadvantages of outpatient surgery

Ambulatory surgery remains difficult to sell to some patients since psychologically they feel better in the hands of hospital staff, not family members, during their recuperation. Some patients live too far away, or their dwellings are not suitable for recuperation. Ensuring adequate postoperative follow-up care becomes more difficult. Where income is generated by paying patients choosing overnight accommodation in the hospital, it might not be economically wise to encourage ambulatory care or shorter stays.

It is said that many countries are following the West's technological jumps in ophthalmic care, but haven't followed the West's shortening of hospital stays.

- Dr. G.N. Rao

In North America and Europe, it is rare to hospitalise an otherwise healthy cataract surgery patient. Cataract surgery is typically an outpatient procedure, as are most other eye treatments.
L..V. Prasad Eye Institute, Hyderabad, India grew from 20 beds to 110 beds, but is now in the process of returning to 20 beds while continuing to increase the number of surgical procedures performed. Funds for the beds are diverted to better equipment. They have actively promoted the option of ambulatory care and now 60-70% of surgery for patients living nearby is done on an outpatient basis. The whole outpatient surgery takes 3 1/2 to 4 hours. When in-hospital care is necessary, LV Prasad Eye Institute keeps patients for only two nights plus the day of surgery, which has lowered costs significantly. Follow-up is then arranged on an outpatient basis, by appointment.
At Aravind and at Lumbini Eye Hospitals, many patients come from great distances. Outpatient care would subject them to difficult dusty journeys during early convalescence, so hospital care is provided.

c. Finances

- How will we establish our compromises and trade-offs in the design of our facility?
- How will we maximise our design features for large volume, high quality, sustainable cataract surgery while minimising cost?
- How do we build in safety features, fail-safe backup systems where needed, and extra capacity without unnecessary, uneconomical "overbuild ing"?
- Do we know people willing to volunteer/donate or provide low prices on services or supplies, for whatever ethical reasons?

Overbuild structure so that heavier floor loads or extra storeys can be handled later; provide excess services capacity; go for oversize ("loose fit") rather than undersize. Separate high- and low-volatility areas and design them differently. Work with shapes and materials that can grow easily, both interior and exterior. "Use materi-als from near at hand," advises builder John Abrams. "They'll be easier to match or replace."

- Stewart Brand

Cost is a difficult topic. Money is always limited. In planning a budget for a building it is critical to remember that the construction is not the whole project cost, indeed it may be less than half. Equally important to consider are the life cycle cost implications of building decisions. Lowest first costs may sometimes be very expensive, if frequent replacement or maintenance or higher energy bills are factored in.

The following components of any building project (not just construction costs) will give you a start in forming a project budget. The components may be handled differently and the numbers will differ from place to place, but most of the elements of this project budget list will be included in your budget in some way, whether charged against the building project or integrated with your operating budget.

1. Land:
   - Purchase price
   - Land holding costs over time such as maintenance, taxes, insurance
   - Pre-development planning and fees
2. Site development:
   - Water, potable water
   - Site drainage
   - Sanitary sewer and/or sewage treatment facilities
   - Electrical hookups
   - Emergency electricity generators
   - Medical gas farms
   - Telephone hookups
   - Paths, roadways
   - Landscaping
   - Parking
3. Building construction:
   - Foundation
   - Structure
   - Weatherproof cladding including windows, sun shades and doors
   - Interior partitioning and finishes
   - Heating and ventilating and air conditioning systems
   - Electrical systems
   - Telecommunications systems
   - Stairs and elevators

Dr. G.Venkataswamy built the first Aravind eye hospital with $5,000 of his own savings and 10 beds. He then built the main hospital in Madurai, India, one floor at a time, with profits from his own operations.

- John Stackhouse

Before constructing the hospital, we collected relevant information about eye hospitals in India and abroad. Doctors from various institutions visiting Aravind provided input regarding OP flow and OT layout. Our 30 years of experience in building construction helped us foresee problems. Even if problems did arise, we were able to solve them immediately. Except for financial support and controlled expenses such as cement and steel, we did not face any other challenges.

- Mr. G. Srinivasan

The client realised - there wasn't money or time to completely remodel the building, but it could be taken by stages, if [the architects] agreed to working that way. [...] They came up with a scheme which specified some areas in the building to be "Cooked" – highly finished and flashy – and some areas left "Raw" – unfinished but usable. The raw parts could be finished later in response to accumulating revenue and to all that would be learned from use of the cooked parts. In the meantime, the raw areas could be tailored roughly by whomever was in them. Postponing some of the design yields more building for less money, since less is spent on detail design and detail finish. And adaptivity is built in.

- Stewart Brand

- Project management
- Contractors' fees and profit

4. Fees:
- Local fees and building permits
- Inspection fees
- Utility hookup fees
- Other site fees
- Assessments, taxes

5. Professional support:
- Architectural design (a package fee may include many of the following disciplines in some cases)
- Structural engineering, mechanical engineering, electrical engineering, civil engineering, traffic engineering, soils/geotechnical engineering
- Project management
- Equipment planning
- Interior design
- Landscape architecture

6. Staff time:
- Hospital administrative staff (project director)
- Medical staff
- Paramedical staff
- Medical information system staff
- Other professional staff
- Maintenance staff
- Cleaning staff
- Security/safety staff

7. Fixtures and fittings:
- Furniture
- Medical equipment
- Business equipment
- Communications equipment
- Computers
- Initial inventory of consumable supplies

8. Other expenses:
- Interest on loans
- Fees to real estate agents, managers
- Insurance
- Moving expenses
- Training time in new structure
- Building commissioning expenses

9. Contingencies:
- Inflation/escalation of costs
- Errors and omissions that add cost
- Cost of time delays caused by weather, approvals process, construction process, programmatic changes, and/or funding difficulties
- Technical changes and advances resulting in changes with added cost
- Substitutions due to material/product unavailability

- Reworking to respond to changes in operations, small adjustments at move-in time
- Mitigation costs for negative environmental impacts, including inconvenience to neighbours and others in the community

While the list is long and the costs are often high, it is best to be complete and clear about costs and and resources from the outset. This way, efforts can be positively focused on realisable goals.

Many programmes have used two strategies to keep costs and resources in balance: set priorities... and do the construction in phases. Few organisations can build everything at once.

7. The Facilities Development Process

Converting old buildings gives plenty of scope for mocking up, chalking out, listening for sound transmission and so on...; we can see what needs to be done next.

- Christopher Day

- Are there any special safety problems to consider (floods, fires, earthquakes, tornadoes)?
- Are there problems with the site (unstable ground, poor water source)?
- Have we considered the "health" of the site?
- What scheduling considerations will we have?

As the building process is complicated, technical and expensive, and as health professionals are typically over committed and not experienced in general construction and project management, a professional project manager should perhaps be hired. Certainly this representative should plan to spend major amounts of time advocating for timely project delivery, quality of construction, value for money, and tending to the design and construction process on behalf of the eye care facility. In essence, this person or company becomes the professional client. In recent years, the magnitude of the work involved has resulted in earlier and earlier appointment of a full-time professional manager on larger projects, sometimes taking charge as a construction manager and at other times as an overall project manager. This person might be part of hospital administration, the general contractor, or someone in the architectural firm.

Building a hospital or clinic differs from country to country, but generally consists of six stages in the design, construction and commissioning process that involve different types of decision-making.

Most of the general considerations outlined here will be similar whether the project contemplated is renovation or new construction. Special considerations for renovation will be ***highlighted * (marked with ***).**

Pre-stage: Site selection

Sometimes getting land for a new facility takes longer than training an ophthalmologist.

- Dr. Suzanne Gilbert, Seva Foundation

Prior to Stage 1 is a phase that can be called pre-planning, master planning, strategic planning or feasibility studies. This phase sets the stage for the actual building project and includes detailed community negotiations for acquiring land or a suitable structure for renovation, establishing requirements for site development (such as site capacity and height limits), and determining the availability of utilities, roads and so forth. Other factors to consider at this stage will depend on your situation

Stage 1: Project description

Often called programming or brief writing, this is the phase when the contents of the project are described (largely in words and diagrams) and tested against the resources available.

Representatives of all functional groups, stakeholders and owners should be involved at this stage. Allocating time for a clear, open and decisive process at an early phase will often save later difficulties, delays and expenses. As the process progresses, changes become both more difficult and more costly.

When we began, we visualised Aravind Eye Hospital as a 40-bed hospital with outpatient facilities. Its present growth was unforeseen. We never expected such an inflow of patients from the camps. [Then] the construction was planned so that the foundation and structure would be able to handle five additional floors at a later date. A three foot wide projection slab was provided all around the floor level on each floor. This enabled maintenance work such as painting, cleaning windows, and sewer line maintenance to be carried out without the need for scaffolding. Temporary staircases constructed outside the building made it unnecessary for labourers to use the staircase inside the building.

- Mr. G. Srinivasan

A thorough project description includes functional requirements and design, space lists, detailed room requirements, technical design criteria and assumptions, cost estimate, project schedule, and site analysis and contextual requirements.

The functional descriptions should provide accurate detail on the tasks to be accomplished, by whom, what priority, etc. It is useful at this stage to identify overall goals of the facility and then to fill in these goals with as much detail as possible in terms of functional patient flow and technical requirements. A complete list of all personnel and their roles is helpful. Estimated numbers of patients to be seen hourly and daily are essential. Projecting building size by housing each function separately is seldom affordable or even desirable. Variations of practice over the day, week or year can be informative in identifying instances where spaces can serve multiple tasks or functions. This is an important opportunity to rethink, as the current process may be constrained by an inadequate facility.

A space list should identify sizes and quantities of spaces. Essential clear, internal dimensions should be identified. Numbers of chairs, beds, operating tables, or other indicators of the number of patients planned for, should be identified.

Adding room by room areas produces a total of the “net usable space” (the area the users use or internal dimensions of usable rooms). To produce the gross area of the building (the area the contractor builds measured from outside wall to outside wall), the net usable area must be multiplied by a factor to account for space needed for walls, corridors, mechanical and electrical equipment, shafts, stairs and elevators. Ignoring this factor, which may range from 1.2 (a very small facility) to 2.0 or even more (a very large facility), can result in serious misunderstandings about needed building size and thus cost.

Detailed room requirements identify critical features such as lighting, temperature and humidity requirements, electrical outlets, etc. Accuracy specific to each function and space will help avoid costly features where not required.

See Appendices 2, 3, 4, 5 - Room Data Sheets

Preliminary equipment lists for major pieces of equipment will be helpful. Collecting manufacturers’ technical brochures on desired equipment will help identify sizes, required clearances (ceiling heights, for example), and service requirements, thus avoiding installation difficulties. This list should be updated prior to purchase in order to include model changes and resulting changes in installation requirements.

Using the above items, an early cost estimate can be prepared with some accuracy. A contingency must be included to account for surprises, omissions and changes, which are bound to occur. Setting priorities is helpful in order to avoid either building a “wish list” at this stage that bears no relationship to resources, or stifling creative thinking because construction is costly.

It is useful to keep facilities costs in perspective. It is important to also consider long-term costs and not just first costs for construction. ***New or

Critical path scheduling is not that difficult, but it is startling how often people forget to do it and then experience unnecessary delays.

- Christie Coffin

Critical path method means using a schedule or diagram of all events expected to occur and operations to be performed in completing a project, done in a way that helps to determine the best sequence and duration of each operation, and thus the time needed to complete the whole project.

- Adapted from The Architects Handbook of Professional Practice, 1994

renovated facilities may be more or less costly to operate than old facilities, depending on what standard the new construction or renovation will be built to***. You must be cautious not to increase the standard too much without considering the additional costs. For instance, how energy efficient is the new building or the renovation? New air conditioning instead of ventilation windows will raise operating costs significantly, and electrical lighting will cost more than daylighting.

Aravind Eye Hospitals' analysis of their eye camp experience led to the construction of base hospitals in urban centres. Although costing more for building construction, increases in physician productivity resulted in significant savings in cost per treatment.

It is often useful to prepare a detailed schedule at this time, including reasonable estimates for internal approvals, community approvals, bidding, delays, weather issues, fundraising, deadlines for funding applications, and so on. This can help identify ways to proceed with several tasks simultaneously and provide a usable health facility in a more timely manner. It may also be critical for estimating inflation and projecting actual costs.

The use of "critical path scheduling" and reasonable time ranges for each task is encouraged. Consultants will often propose very optimistic construction schedules to indicate a "can do" attitude, and then blame delays on public agencies and the like. In practice, these optimistic schedules are easily discredited and disregarded. A schedule that has some "give and take" will gain in credibility over time, offer opportunities for management success, and keep the process moving at a realistic pace. Often, health facilities are out of date by the time they are constructed. It is good to remember this and plan for flexibility.

Stage 2: Project design

This phase often consists of two sub-phases: Schematics, when a concept is drawn up for discussion and review, and Design Development, when the concept is explored in more detail and drawn up quite precisely. In some countries, construction is completed with detailed design drawings similar to design development drawings.

It is during this phase that architects creatively try to meet the requirements outlined in the detailed project description created in Stage 1. The building moves from a set of parts and a concept to a material reality in this phase. Discoveries are made. Assumptions are tested. Questions are raised. Changes are made. New cost estimates, equipment lists, specifications lists and schedules are made, and scope is adjusted to meet the reality of resources available.

In the case of renovation, detailed as-built drawings are essential before proceeding with design. Original documents often do not reflect changes made during the original construction or through subsequent modifications. Accurate field observations and measurements will be necessary for the preparation of a usable as-built set of drawings. Budgetary contingencies should be included for unobservable conditions and services that may add costs during renovation.

At this phase, full-scale mockups can be fabricated in existing facilities. Mocking up a repetitive or expensive architectural element will save time, money and disappointment. A mockup may be as simple as rearranging furniture in an existing space so that staff can test functionality, or as complicated as remodelling an area such as a patient toilet facility, surgical space or examining room for actual use in anticipation of a future construction project. Mockups produce a workable prototype that can be refined for greater efficiency.

To achieve better quality control and better value for money, formal or informal peer reviews can be scheduled during this Project Design stage, when changes are still practical with minimal costs in terms of time and consultation fees.

Value engineering is sometimes employed on larger North American construction projects. A symposium is arranged where outside architectural, engineering and construction experts are assembled to meet with the design team to critique and improve on the design. When done with a collaborative intent and minimal bureaucracy, major improvements in quality and value can be economically achieved. This technique should be used cautiously, as many feel that value engineering has the potential to add a burdensome amount of work, especially if used in a heated political environment, and could result in little real benefit.

Stage 3: Project documentation

The approved results from Stage 2, a complete set of plans, elevations, outline specifications and representative details, are now used to create a set of instructions known as construction documents for the contractor. Theoretically, the architect and his or her set of consultant engineers and other consultants can produce a set of documents at this phase with little contact with the hospital administration and staff. In reality, questions arise and hospital participation will assure a more satisfactory result. Detailed changes occur at this phase as dimensions are checked and finalised, constructability tested, equipment specified, long lead items ordered, product availability verified, colours and textures chosen.

In a renovation project, demolition can be fully accomplished at this stage, preparatory to remodelling. If this is not practical, selective demolition may be used to reveal conditions critical to the design and accurate cost estimation.

In Japan, it is common for the architect's drawings to be altered radically on the building site. All such sites have field offices, known as genba, where architects and builders work together. This helps them to collaborate on the unforeseen problem of detail, the sudden glitch.

- The Economist (22 August, 1992)

Stage 4: Pre construction

Before construction can commence, project documents are used to secure bids and to receive government permits for construction. The architects' and engineers' ongoing quality control efforts can now be tested by a full constructability review of the documents by knowledgeable experts who have not been part of assembling the documents. Corrections can be included in the drawings prior to negotiation and signing of contracts. The contractor may be involved in this constructability review, particularly if the contract is to be negotiated rather than bid.

In North America, competitive bidding on the open market has traditionally been the cheapest approach to general contractor procurement, though in recent years it has also resulted in a contentious and time consuming construction management process that features a significant level of litigation. For a period of time, Canada employed a system of bidding called Canadian Averages, in which the high and low bids were discarded and the contract was tendered to the contractor submitting the median bid of those remaining. This system attempted to seek a "fair price" for the work requested. Other approaches have been employed to balance speed, quality and cost control. Recently, some clients have been prequalifying bidders and then negotiating a fair price. "Fast track" or "design-build" can be employed to perform some of these tasks during earlier phases. In fast track, the project is broken into several sub-projects such as (1) demolition, site work and foundation, (2) structure, shell and rough utilities, and (3) tenant improvements, in order to allow construction to start and end more quickly. Design-build has a similar effect through combining the designer and the contractor into one company and permitting expeditious pursuit of completion.

Selection of the system likely to produce the desired balance of speed, quality and cost control varies from community to community, from decade to decade, and requires a conscious and informed choice by individuals knowledgeable in local contracting and construction practices.

The construction sequence is strictly in order: Site preparation, then foundation and framing the structure, followed by skin to keep out the weather, installation of Services, and finally Space plan. Then the tenants truck in their Stuff.

- Stewart Brand

Stage 5: Construction

Construction is an exciting, rough, problem-solving process. Buildings are usually prototypes and not tested models. Drawings contain errors and omissions. ***On renovation jobs, concealed conditions are unveiled, requiring changes and additional work.*** Materials and equipment are not available on schedule. Contractors make mistakes and have other jobs to schedule. Local building officials enforce rules in unexpected ways. Appropriate building crafts people and labourers may not always be available. Weather intervenes. Questions arise and must be quickly answered to keep things moving.

Someone who understands the nature of local construction and who can be firm, decisive and encouraging to the contractor must represent the health facility's management. The first priority is to solve problems expeditiously and keep the construction process moving. The second priority is to proceed in a fair, equitable manner so that the contractor is compensated for extra work and at the same time makes good on problems of his or her own creation. An effective project manager can save the client both time and money, and can improve the quality of the end product.

The art of architecture is not only to make beautiful things, nor is it only to make useful things, it is to do both at once — like a tailor who makes clothes that both look good and fit well.

- Herman Hertzberger

Stage 6: Post construction

Commissioning the building includes testing mechanical, electrical and plumbing systems and making appropriate adjustments. Building maintenance staff will often need training in new systems. While many will be enthusiastic about the new or renovated building, there will be problems. A modest budget for move-in and the immediate solution of problems will smooth the way to providing excellent care. Someone who understands which problems are serious enough to deserve immediate attention must represent the hospital.

It is a good idea at this point to keep in mind that many hundreds of thousands of decisions go into making a building. Not all decisions will have been made to the satisfaction of all users, even in the rare situations where resources were virtually unlimited. While blame frequently must be assessed and penalties paid, the first order of business is providing medical care for patients. It is therefore wise to delay post-occupancy evaluation until a building has been in use for one full year.

However, in the United States, architects and contractors are responsible for the building only for the first year. Find out when your builder's liability runs out, and ensure that your post-occupancy evaluation takes place before then. Keep a list of design features that have worked well – that you would repeat or share with others – and a list of problems and potential solutions or how you actually fixed them.

And be sure not to blame the building for problems in your hospital's management systems or organisational structures. The Management Principles and Practices Module suggests effective ways to organise high quality, large volume, sustainable cataract surgery programmes.

Conclusion

We need new models for attractive, functional, sustainable health care facilities. The facilities in India built by Aravind Eye Hospitals and L.V. Prasad Eye Institute, and Lumbini in Nepal built by the Seva Foundation and Seva Service Society, have much to teach us. We have much more to learn. It is hoped that subsequent editions of this module will include innovative ideas from other eye care facilities around the world.

Appendices

Appendix 1
Conversion Tables

Length	(Conversion factor)			
feet (ft)	x	.3048	=	metres
yards (yd)	x	0.914	=	metres
miles (mi)	x	1.609	=	kilometres
metres (m)	x	3.281	=	feet
metre (m)	x	1.093	=	yards
kilometre (km)	x	0.6215	=	miles

Area				
square feet	x	0.0929	=	square metres
square yards	x	0.8361	=	square metres
square miles	x	2.588	=	square kilometres
acres	x	0.4	=	hectares
sq m (m^2)	x	10.76	=	sq yd (yd^2)
sq km (km^2)	x	0.386	=	sq mi (mi^2)
hectares (ha)	x	2.5	=	acres

Temperature			
Fahrenheit	- 32 x 5/9	=	Celsius
Celsius	x 9/5 + 32	=	Fahrenheit

Appendix 2
Room Data Sheet (Template)

A sheet such as this "room data sheet" is helpful for keeping track of requirements room by room. In this format many who cannot read drawings well can check to make sure that their requirements are included in the thinking about the new facility. The cost estimator will find this sheet helpful in itemising and counting desired features for cost control. Several examples follow for typical spaces.

Room Data Sheet **Name of space** **Area (in m^2):**

Functional Description

Adjacency

Structural Requirements

Finishes

Minimum Ceiling Height

Plumbing

Medical Gases

HVAC (heating, ventilating and air conditioning)

Electrical Power

Lighting

Telecommunications

Fire Protection

Fixed Equipment

Major Movable Equipment

Appendix 3
Room Data Sheet (Surgical)

Room Data Sheet	**Ophthalmic Operating Room (Surgical Theatre)**	**20 - 45m^2**
Functional Description	Surgical space for one to four ophthalmic surgical procedures with circulation space for surgeons, ophthalmic nurses, technicians and multiple patients.	
Adjacency	Space should be adjacent to patient preparation and waiting, patient recovery, instrument sterilisation facilities, scrub sinks and staff dressing rooms.	
Structural Requirements	Ceiling must be strengthened to support heavy surgical lights, ophthalmic microscope(s), video monitors, and other devices. A steel structure is often the most reliable.	
Finishes	Smooth, nonabsorbent, easy to clean, coved at corners Floor: stone, terrazzo, sheet vinyl, glazed ceramic tile Walls: glazed ceramic, since constant scrubbing takes its toll on almost anything else Ceiling: painted plaster, painted plasterboard, scrubbable metal panels	
Minimum Ceiling Height	3.2 m, low ceilings impede use of required ceiling mounted equipment.	
Plumbing	Plumbing is generally provided in adjacent spaces, such as scrub alcove off corridor as it is thought that plumbing introduces dirty water through aerosol as hands are washed. No floor drains (due to potential for adding contamination).	
Medical Gases	Oxygen, vacuum, medical air, N_2 and NO, access at each operating table.	
HVAC	A very clean environment is sought, which can usually only be maintained by a forced air system of air conditioning with proper filtration. Air is typically introduced at the ceiling with the aim of providing a wash of clean air at the surgical site and return is accomplished near the floor which is thought to be the dirtiest part of the room. Cooler air temperatures, for example 18-22°C, are generally sought in surgery due to the multiple layers of clothing worn by gowned personnel and the heat generated by the surgical lights	

Electrical Power	3 duplex outlets minimum per patient at operating table, additional outlets needed at periphery, uninterrupted power supply (UPS)
Lighting	100 foot-candles general illumination, no direct glare, indirect or shielded light sources desired, intense illumination on surgical site with special focused surgical lights, ability to darken room desirable, daylighting acceptable with easy to use window covering. Emergency lighting.
Telecommunications	Telephone and data lines, access path to systems.
Fire Protection	Sprinklers and/or smoke detectors.
Fixed Equipment	Surgical lights, operating microscopes, optional video equipment.
Major Movable Equipment	Surgical tables, trollety, revolving stools, vitrectomy machine, cryo, cautery, Boyle Apparatus, Suction apparatus, ECG machine, pulse oxymeter, phaco machine, etc. (Fill in.)

Room Diagram

Ophthalmic Operating Room (Surgical Theatre)

Appendix 4
Room Data Sheet (Diagnostic)

Room Data Sheet	**Ophthalmic Diagnostic Room**	**10 - 14 m^2**

Functional Description	Patient examination and diagnosis space for one or two physicians, each serving a patient. If designed for two physicians some sharing of costly equipment is easily arranged.
Adjacency	Space should be adjacent to patient waiting, several other exam rooms, nursing support station, and a minor treatment room equipped for simple treatments.
Structural Requirements	No special needs.
Finishes	Smooth, nonabsorbent, easy to clean Floor: stone, terrazzo, sheet vinyl, (carpet OK in very clean, dust free neighbourhoods) Walls: painted plaster, painted plasterboard Ceiling: painted plaster, painted plasterboard (acoustic tiles, if they can be kept clean)
Minimum Ceiling Height	2.4 m minimum; higher ceilings are desirable in hot climates where natural cooling techniques are employed
Plumbing	1 hand wash sink with hot and cold running water in room (or near entry and shared with next room for economy).
Medical Gases	Not essential
HVAC	Maintaining comfortable, relatively dust free environment is desirable. Winter: 18-22°C. Summer: 22-26°C or slightly higher with fan or breeze. (These are US standards for comfort levels; adapt accordingly.)
Electrical Power	3 duplex outlets minimum, one for each of two work stations, one for slit lamp. Area where power sensitive equipment (Scans, Computers, Automated Field Analyser, etc.) will be used must have UPS outlets.

Lighting	35-50 foot-candles illumination, no direct glare, indirect or shielded light sources desired, task lighting, ability to darken room desirable, daylighting acceptable with easy to use window covering.
Telecommunications	Potential for telephone and data lines, access to systems.
Fire Protection	Sprinklers and/or smoke detectors.
Fixed Equipment	None
Major Movable Equipment	Slit lamp, Indirect ophthalmoscopic table (optional), etc. (Fill in.)

Diagram of the Diagnostic Room

Appendix 5
Room Data Sheet (Patient Bedroom)

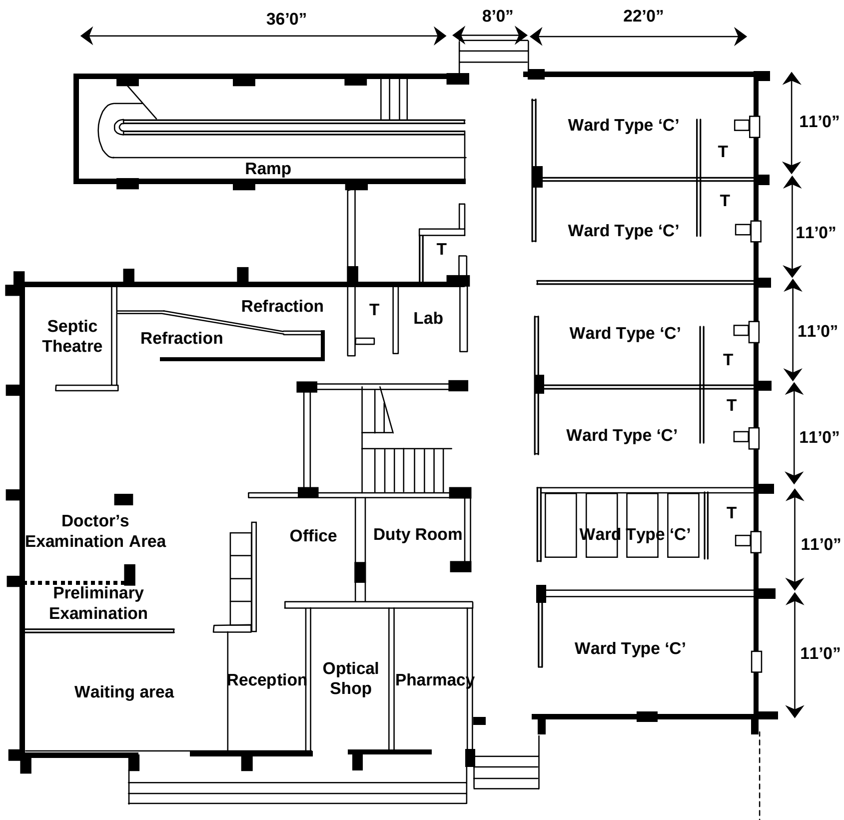
Room Data Sheet	**Patient Bedroom (private)**	**12-16 m^2**
Functional Description	Quiet room for rest and recuperation of one or two patients with provision for all activities of daily living such as eating, sleeping, washing, and seeing family and friends (plus bathroom at 5-6 m^2).	
Adjacency	Space should be adjacent to nursing staff center with staff on call and space for records, medications, medical supplies, food service, wastes and recycling, housekeeping.	
Structural Requirements	No special needs.	
Finishes	Smooth, nonabsorbent, easy to clean. Floor: stone, terrazzo, sheet vinyl, VCT, ceramic tile (carpet OK in very clean, dust free neighbourhoods). Walls: painted plaster, painted plasterboard. Ceiling: painted plaster, painted plasterboard (acoustic tiles, if they can be kept clean).	
Minimum Ceiling Height	2.4 m minimum, higher ceilings are desirable in hot climates where natural cooling techniques are employed.	
Plumbing	1 hand wash sink with hot and cold running water in room (or near entry and shared with next room if economy dictates). En suite or nearby toilets and bathing facilities should be provided.	
Medical Gases	Not generally essential for eye care, although medical gases are desirable in some ophthalmic bedrooms, especially for intensive care.	
HVAC	Maintaining comfortable, relatively dust-free environment is desirable; local standards for comfort should be consulted; in hot climate a ceiling fan and cross ventilation may be very desirable. Winter: 18-22°C, summer: 22-26°C or slightly higher with fan or breeze (These are US standards for comfort levels; adapt accordingly.)	
Electrical Power	3 duplex outlets minimum, two at bed, one general additional outlet, desirable for medical equipment, computers, television set or other amenities.	

Lighting	35-50 foot-candles illumination, no direct glare, indirect or shielded light sources desired, higher intensity lighting desirable for cleaning and for patient examination, daylighting necessary with easy to use window covering to darken room.
Telecommunications	Potential for telephone and data lines, access to systems.
Fire Protection	Sprinklers and/or smoke detectors.
Fixed Equipment	None
Major Movable Equipment	Beds, tables, chairs, bed for kin.

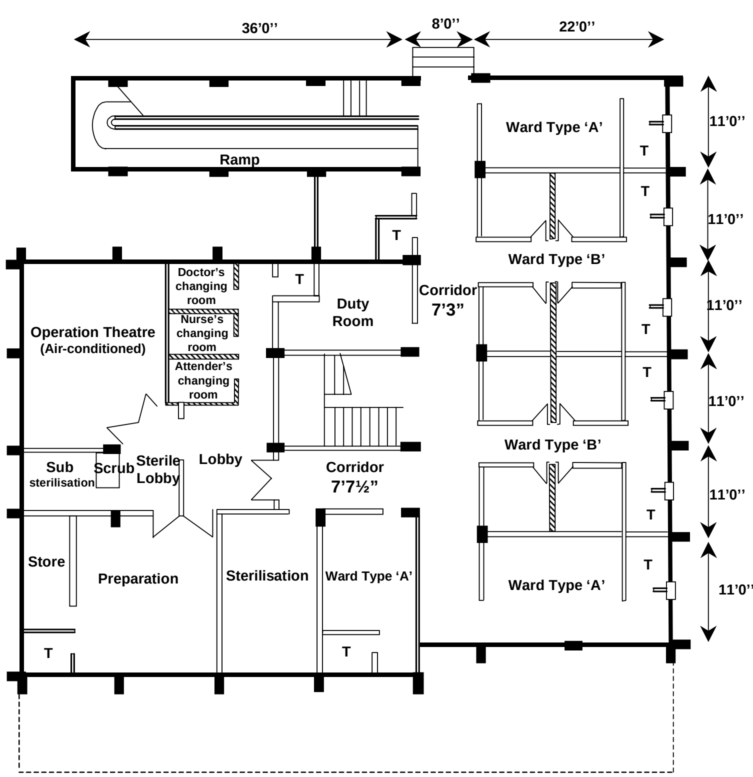
Diagram of the Patient Bedroom

Appendix 6
Floor Plan for Aravind Eye Hospital, Theni (100 Beds)

Ground Floor Plan



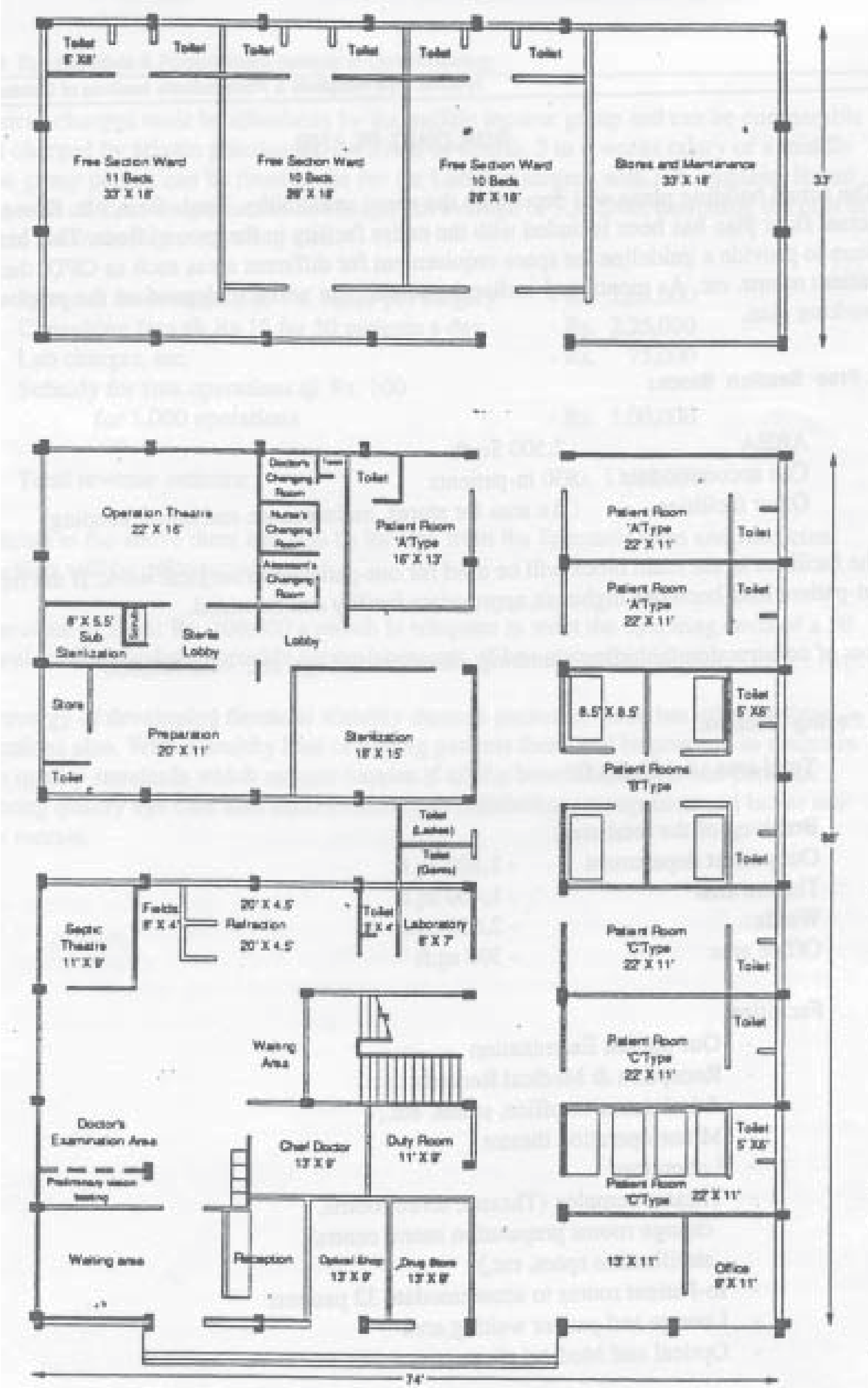
First Floor Plan



Appendix 7

Floor Plan for 50-Bed Rural Eye Hospital

by Mr. G. Srinivasan, Aravind Eye Hospitals



Appendix 8
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